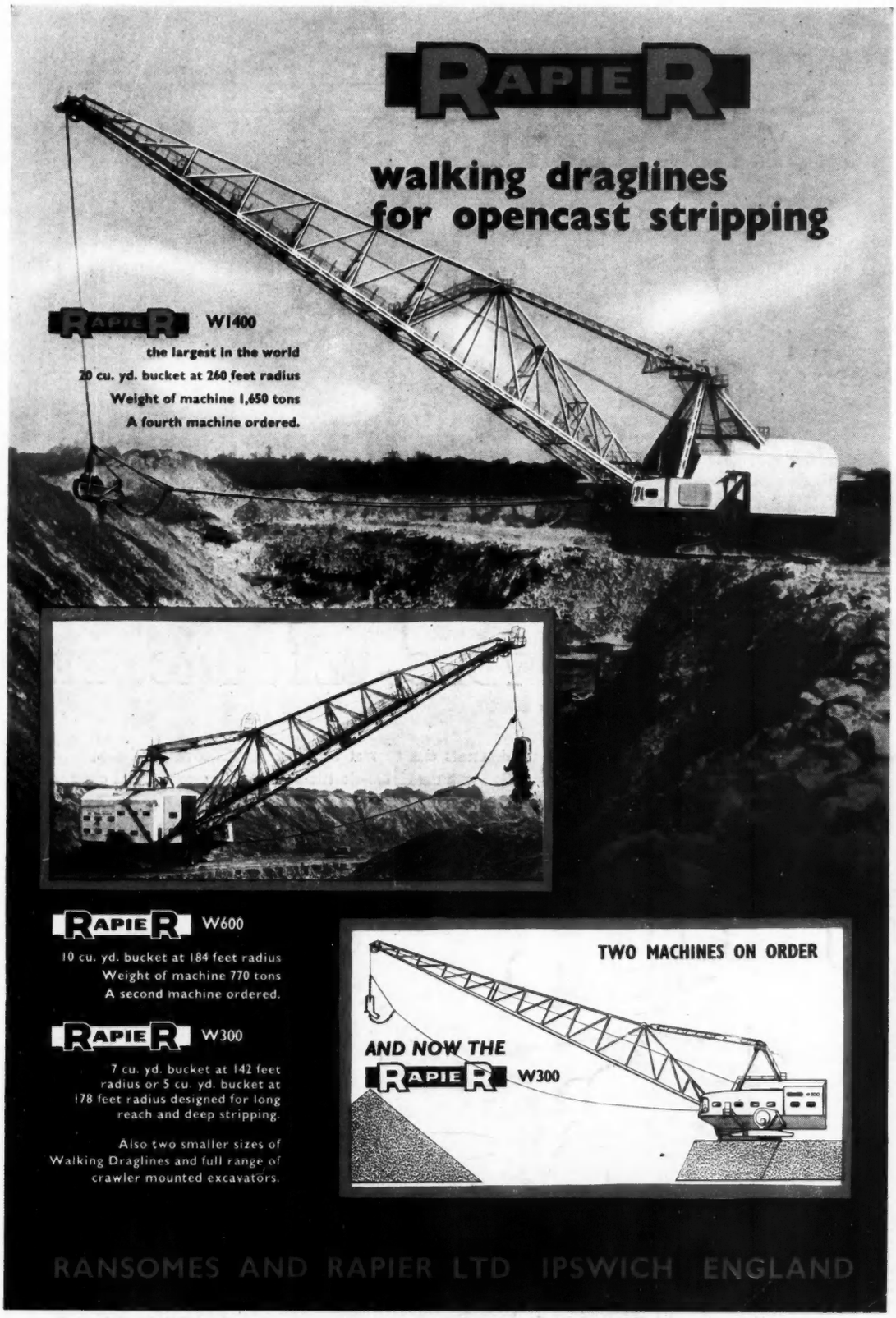
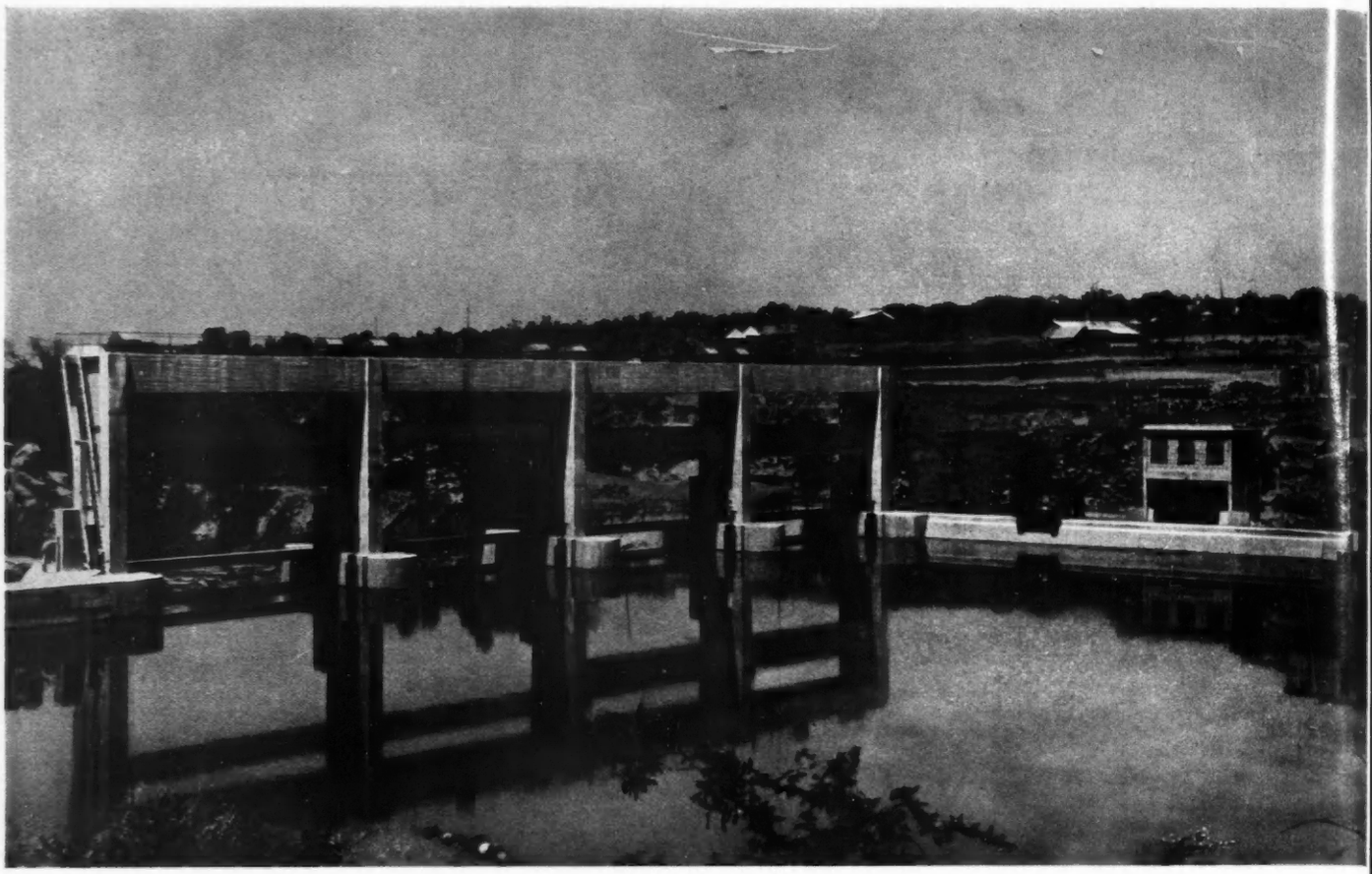
The Engineer

MAY 3, 1957 — 28 ESSEX ST., STRAND, LONDON, W.C.2 — TWO SHILLINGS

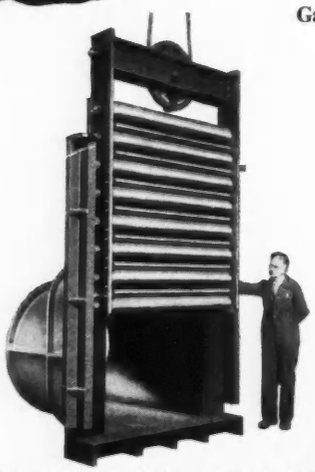
UNIVERSITY OF MICHIGAN
MAY 21 1957
ENGINEERING LIBRARY

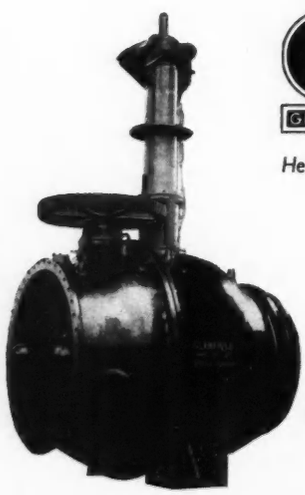

RAPIER
walking draglines
for opencast stripping
RAPIER W1400
the largest in the world
20 cu. yd. bucket at 260 feet radius
Weight of machine 1,650 tons
A fourth machine ordered.
RAPIER W600
10 cu. yd. bucket at 184 feet radius
Weight of machine 770 tons
A second machine ordered.
RAPIER W300
7 cu. yd. bucket at 142 feet radius or 5 cu. yd. bucket at 178 feet radius designed for long reach and deep stripping.
Also two smaller sizes of Walking Draglines and full range of crawler mounted excavators.
TWO MACHINES ON ORDER
AND NOW THE
RAPIER W300
RANSOMES AND RAPIER LTD IPSWICH ENGLAND



If its Equipment for

HYDRO-ELECTRIC PROJECTS





all requirements can be met from the Glenfield range—built-up over many years of association with the Hydro-electric field—for flow control and other purposes at the Dam and Intakes in the Pipelines and in the Power House.

The site illustration shows the Merila Barrage and Intake Works of the Low Tana Scheme in Kenya, constructed by Balfour, Beatty & Co. Ltd., for the East African Power and Lighting Co. Ltd., which incorporate Glenfield Sluice Gates, Screens and Screen Rakes. Also shown are typical examples of Butterfly Valves, Free Rolling Emergency Gates, and Needle Valves.

Glenfield

GLENFIELD & KENNEDY LIMITED KILMARNOCK

Head Office and Works: KILMARNOCK, SCOTLAND

VALVE SPECIALISTS AND HYDRAULIC ENGINEERS FOR OVER 100 YEARS

THE ENGINEER

VOL. 203 No. 5284 MAY 3, 1957

CONTENTS

LEADING ARTICLES—
British Steel ... 667
The Air Deterrent ... 668
European Free Trade ... 668

ARTICLES—
Beyer - Garratt Locomotives for Rhodesia Railways... 669
British Columbia-Vancouver Island 138kV Submarine Power Cable. (Illus.) ... 678
British Industries Fair. (Illus.) ... 684
Damping Capacity. (Illus.)... 671
Datum Selection in the Drawing Office. (Illus.) ... 675
Defensive Missiles. (Illus.) ... 694
Doubling and Electrification of South African Main Lines. (Illus.)... 696
Dr. G. E. Foxwell, C.B.E. ... 669
Fuel Efficiency... ... 687
Gas Turbine Design Details. (Illus.)... 690
High-Temperature Laminating Resin... 689
Hinge Making Factory. (Illus.) ... 693
Junior Institution of Engineers' Dinner 669
Mechanised Sorting Equipment for the Post Office. (Illus.) ... 688
Opening of Wadding Mill ... 669
Rotor Tip Pressure Jets. (Illus.)... ... 686
Sir Murdoch MacDonald ... 670
Strength Calculations of Bolted Joints. (Illus.) ... 674
Trends in Canadian Railway Equipment 673
Two-Speed Portable Electric Drill. (Illus.) ... 694
Ultrasonic Flaw Detection Equipment for Large Plates. (Illus.) ... 692
132kV, 5000MVA Outdoor Oil Circuit Breaker. (Illus.) ... 691
100 Years Ago... ... 668

CONTINENTAL SECTION—
German Industries Fair, Hanover. No. I. (Illus.)... ... 697
European Coal and Steel Community... 698
Radio Isotopes in Scientific Research... 698

AMERICAN SECTION—
Experimental Boiling Water Reactor at the Argonne National Laboratory. No. III. (Illus.) ... 699
Large Vacuum Impregnator for the Pakistan Railways ... 701

LETTERS AND LITERATURE ... 682

NEWS AND NOTES—
British Patent Specifications. (Illus.)... 703
British Standards Institution... ... 696
Catalogues and Brochures ... 704
Forthcoming Engagements ... 704
Industrial and Labour Notes... ... 695
Launches and Trial Trips ... 704
Personal and Business ... 702

BRITISH STEEL

The latest annual report of the British Iron and Steel Federation is, like the majority of its predecessors, an impressive document. It deals, of course, with the year 1956, and consequently most of the figures and many of the facts which it contains have already been published. But by bringing them together, the report presents a useful record of the iron and steel industry's continuing progress and foresight in the year which completed the first post-war decade.

Ten years ago, the British iron and steel industry was beginning work on a programme of planned expansion designed to provide the capacity necessary for an annual ingot production of 16,000,000 tons. The estimated cost of the work involved was then £168 million but the ensuing economic situation quickly made it clear that that figure would be considerably exceeded. At the same time, there was an acute shortage of fuel and most other raw materials, and there were also the perplexities and uncertainties created by the Labour Government's determination to nationalise the steel industry. Yet none of these difficulties deterred the industry from forging ahead with the fulfilment of its plan for expansion. By the end of 1953, no less than £310 million had been expended, and in that year steel output reached 17,608,000 tons, compared with 12,695,000 tons in 1946. Thus, the annual production rate was well in excess of what had been forecast, the prime factor in that achievement being the extended capacity. There were other important factors; some of the older plant was kept in operation longer than had been expected, continuous working was introduced through ready co-operation between managements and the unions, and there was much better availability of imported scrap than had been anticipated. But even though British steel production was increased by 40 per cent in the relatively short space of seven years, it by no means matched up to the ever-growing demand. As the extensions specified in the first post-war programme approached completion, details of a second development plan were worked out. That programme specifies a steel output of 22,000,000 tons in 1958. As production last year amounted to 20,660,000 tons—despite some loss occasioned by the first labour dispute in the industry for many years—the latest target will, no doubt, be exceeded. An output next year of about 24,000,000 tons is, in fact, already envisaged.

The Federation's report completes the record of ten arduous, yet highly successful years. Taking the whole of that period, British steel production has increased by 63 per cent and pig iron production by 70 per cent. Calculated at present-day prices, the steel companies have spent £710 million on new plant and equipment, and their investment expenditure is now running at the rate of about £100 million a year. It is facts of this kind which emphasise that an expanding steel industry is one of the first essentials of an expanding economy. All who are in any way concerned with the British iron and steel industry are keenly aware of that. Now, the industry is busy about its further development, and is looking forward to there being sufficient capacity for an annual steel output of 28,000,000 tons by 1962. Its latest proposals, like those that are now coming fully to fruition, do not overlook the need to provide for a properly balanced steel production. Over the past year there have been recurring complaints about the shortages of steel plates and heavy sections, but there is reasonable hope of continuing improvement in the supplies of these products as work on the current expansion schemes proceeds. But even though there may be criticism from time to time about prevailing shortages, there is a general readiness to accord high praise to the steel industry for its achievements over the last ten years. Such praise is deserved. It should not be thought, however, that the industry itself underestimates the problems which it must solve in the near future if its present aims are to be fully realised. The Federation's report says frankly that some of these problems are formidable. The supply of ore and other raw materials sufficient to provide a steel output of 28,000,000 tons a year is, for example, one matter which is now receiving careful and urgent consideration. Another pressing problem is indicated by the statement that the steel price increases, averaging 6 per cent, which were authorised at the end of last year, took only "some account" of the heavy cost of new plant equipment. On that score, the report says that "adequate prices are essential for the future if sufficient funds are to be secured from either internal or external sources to sustain the industry's plans for capital expenditure." In this day of rising costs, British steel is sold at prices lower than those charged by the majority of the other steel-producing countries of the world, for the industry's post-war development plans have involved more than the renewal and expansion of plant. They have included many technical advances leading to greater efficiency and productivity, the benefits from which are reflected in the prices paid by steel users.

THE AIR DETERRENT

In his memorandum accompanying the Air Estimates, the Secretary of State for Air makes clear that the ballistic rocket is still a long way off as far as Britain is concerned and that for many years to come we shall have to rely on the V-bomber as the foundation of our deterrent power. In view of our limited financial and manpower resources, it is essential to concentrate on the types of deterrent which make no appreciable increase in overheads in terms of men, aircraft and airfield installations. Our V-bombers are, therefore, to be developed to carry an air-to-surface guided missile which will both extend their effective range and also their operational life. The missile is in fact a pilotless aircraft—about the size of a small fighter. Immediately after release from the bomber, its engine starts up and the missile climbs very rapidly to a great height and makes a steep dive on to the target. Whether Britain is to manufacture or purchase these missiles is not clear but it is worth noting that the United States will shortly have a flying bomb of this kind—the "Rascal"—in production, with a range of 100 miles. Another offensive missile which calls for no radical alteration in our operational planning or methods of control is the guided winged surface-to-surface missile—the self-propelled bomber. Relative to the contemporary manned bomber, it can be given greatly superior range, height and speed because no provision has to be made for the crew and because it is a one-way vehicle. It is also cheaper than the manned bomber and with booster take-off can be launched from a very small area. On the other hand, its accuracy is marginal and it is much more vulnerable to enemy defence measures than the smaller "stand-off" bomb launched from a V-bomber. Intercontinental versions of this missile are under development in the United States and there are already two types with a 500-mile range in service in the U.S. Armed Forces—the "Matador" in the air force and the "Regulus" in the navy. Finally, the ballistic rocket, with its invulnerability to defence measures of any kind, seems to be the ideal deterrent weapon. But an Air Ministry spokesman emphasised that the main difficulty is still the re-entry into the earth's atmosphere at a speed of 4 to 5 miles a second without burning up like a meteorite. The Americans claim to have overcome this difficulty in rockets with a range of up to 1500 miles and it is these missiles which are to be supplied to Britain under the recent agreement between the President and our Prime Minister. But, launched from Britain, they would not reach vital targets in Russia, and it seems, from the priority to be given to the air launched guided flying bomb, that we have not yet decided on our rocket policy. Are the rockets provided by the United States to be adapted for firing from ships—as is now being done in the United States Navy—or are we to wait for rockets with ranges of over 2000 miles ?

The Minister also, for the first time, gives encouraging news of the anti-aircraft guided missile which has hitherto been developed in this country behind a curtain of secrecy. The "Fireflash," an out-of-date air-to-air guided missile which has been used by the R.A.F. for operational training, is to be superseded by the de Havilland "Firestreak." This missile is about to begin its acceptance trials. It operates on the infra-red homing principle and is to be fitted to the "Javelins" and "P.1.s." An improved version of it is under development. The brunt of our overall air defence will for some time yet be taken by manned fighters and, apart from the need for elaborate workshops and advanced servicing technique, the arming of fighters with air-to-air guided missiles can be accomplished quite smoothly in the existing organisation. It is thus high time that a production order has at last been given for a supersonic fighter—the "P.1."—and that concurrently an efficient guided missile has been produced both for this aircraft and the all-weather "Javelin." None the less, it must be recognised that the increasing threat of the supersonic bomber can only be met by air defences which are largely automatic in operation. Moreover, apart from its greater effectiveness, the surface-launched defence system has two important advantages as compared with manned fighters. It can be maintained in a high state of readiness by a relatively small personnel ; and the running costs are a good deal lower than with a contemporary fighter system. Happily, the Secretary of State is able to assure us that progress is at last being made with ground-launched anti-aircraft missiles. The first R.A.F. missile station is now under construction at North Coates and will be brought into use for service trials next year. Equipment has been ordered for an initial operational deployment of ground-to-air missiles of the semi-active homing type with a ram jet engine and developed by Bristol and Ferranti. It is also very satisfactory that a new organisation is to be set up in the Air Ministry to co-ordinate and speed up the introduction of defensive guided missiles and their associated radar systems.

The Engineer
100 Years Ago

(MAY 1, 1857)

"THE GREAT BEE-HIVE"

"Will London ever be improved, or only enlarged ? To this question every one will reply, 'It must be ;' but no one has yet ventured to assert, when. The necessity has been apparent for a long time. It has been what is called a *crying* necessity for the last fifteen years or more, and is so still ; and the schemes proposed for its accomplishment present every variety of feature, from the most soberly conceived piece of patchwork, to the most reckless ploughing up of houses, and disregard both of public and private rights. The propositions include railways over the houses, under the houses, and alongside the houses, and now we have them, for a change, actually *through* the houses....

"London must shortly, nay, very shortly, be improved, unless, at certain places, and at certain times in the day, we make up our minds to creep upon each other's heads like cheese mites. We cannot increase the rate at which people walk, neither can we do much in the way of expediting the pace of horses, so as to shorten the time of their journeys through the streets, and thus keep them cleaner. We must, consequently, increase the present area used for communications between one part of the town and another. This may be done in two ways : we may widen the present streets, or make new ones ; or, by a process of bookcase making, we may pile houses upon railways, or *vice versa* ; or we may place railways over the ordinary carriage ways—a plan which has obtained, not inaptly, the name of the 'lamp-post system.' In making entirely new thoroughfares we have also the choice of underground tunnels ; or, as regards an east and west-end communication—which is the most important of all—an encroachment upon the river, part of whose area is at present devoted for many hours in the day to mudlarking, the interest in which ancient and profitable sport, only appertaining to small boys and thieves, might possibly be bought by a reasonable outlay."

EUROPEAN FREE TRADE

There has been issued by the Federation of British Industries a publication surveying the situation that has been created by the decision—still to be ratified—of Belgium, France, Germany, Italy, Holland and Luxembourg, to create a customs union amongst themselves ; and the negotiations now going forward between this group and certain other nations, including Norway, Denmark and Sweden and this country, for the formation of a Free Trade Area in Western Europe. Under the British proposals, it will be remembered, all customs duties will be removed within the Area except upon commodities coming under the designations food, drink and tobacco, the object of the exception being to retain a preference in the United Kingdom market for Commonwealth products in return for the preferences granted within the Commonwealth in favour of United Kingdom products. Some 50 per cent of this country's exports go to the Commonwealth and about 25 per cent to Western Europe. The purpose of the F.B.I. publication is not to commend the proposals to readers nor to express criticism. What it sets out to do is to give briefly a picture of the existing state of the several means by which internationally the nations concerned now co-operate, to review existing customs practice and to show how they would have to be modified, and to describe briefly how necessary it will be to devise common rules

of competition and safeguards against unfair practices. The thorny question of the inclusion of colonial territories within the Free Trade Area is also shortly discussed.

The publication, neutral though it is towards the central question as to whether or not this country should participate, is peculiarly welcome as, besides providing much information in itself, it gives guidance as to where more can be found and as to the particular matters that industry will need to watch when the time comes to comment upon and criticise any definite proposals made by our Government. Naturally enough, different industries will look at the proposals in different ways. Industries dependent upon sales abroad may welcome the opportunity the scheme offers for expanding sales on the Continent. But an industry supported primarily by the home market cannot be expected to welcome open competition from European firms. Yet the one thing which, it seems to us, would be fatal to this country's prosperity would be to adopt a policy of having nothing to do with this Continental development. Whether or not the Free Trade Area comes into being, industrial readjustment will be necessary here, either in acceptance of the difficulty of competing in Europe at all, over the barrier of high customs around the union, or in accepting the challenge of Continental products in our own home market in exchange for the virtual extension of that home market over most of Western Europe. The very purpose of the creation of a great duty-free market of 200 to 250 million people will be to encourage the rationalisation of production and to reduce costs either by siting industry where its costs will be lowest or by favouring the more efficient and vigorous concerns. Though it is possible that certain industries and firms here may prove unfavourably situated to compete, we do not believe that, given twelve to fifteen years in which to adjust, British industry can do anything but benefit as a whole from the changed circumstances. There is no reason at all to believe that the scheme could reduce the demand for the products of our capital goods industries; whilst the creation of a "home" market of up to 250 million people provides a challenge for consumer goods industries. Attention, we feel, should be concentrated not upon attacking or defending the scheme, nor too exclusively upon considering the effects upon individual industries. Rather should attention be directed to the devising of "rules" for the Free Trade Area which, besides making trade really free, will also ensure parity for all to take advantage of the opportunities that will be offered. By providing basic information and directing attention to that point, the compilers of the F.B.I. booklet have done industry good service.

A Seven Day Journal

Junior Institution of Engineers' Dinner

On Friday, April 26, the Junior Institution of Engineers held its Annual Dinner at the Connaught Rooms in London. The toast list was longer than is now usual at such affairs but mercifully the speakers expressed themselves briefly and even though it could be said of some of the speakers that they were not very instructive they were at least entertaining to listen to.

The toast of the Institution was proposed by Sir Henry Jones, President of the Institution of Gas Engineers. He referred to the very high demand for water, power and chemical engineers in gas works and he looked forward to the day when gas generation and coking would be carried out at pressures up to 20 or 30 atmospheres, thereby permitting "any old coal" to be used for the purpose. He also told some entertaining stories about really small gas works, the kind small enough to be operated twenty-four hours a day by a man and his wife! Mr. J. E. Gray, Chairman of the Institution, in his reply, stressed how in an age of increasing specialisation the "Juniors" remained unspecialised. Sir Henry Clay proposed the toast of Heat-Electric Generation and the Future and Mr. Bryan Donkin, in his reply, stressed how great was the work of engineers in cementing laboratory studies into full-scale engineering devices. The profession needed all kinds of men, from those interested in research to those practised in manual skills.

The toast of the Guests was proposed by Mr. Peter Cameron, Vice-Chairman of the Institution, and Mr. H. S. Cheetham, Vice-President, Institute of Fuel, replied. Mr. W. C. C. Ball, Vice-Chairman of the Institution, then proposed the toast of the Chairman, to which Mr. Bryan Donkin responded.

Opening of Wadding Mill

On Tuesday, April 30, H.R.H. the Duke of Edinburgh paid a visit to the Aylesford paper mills and converting factories of the Reed Paper Group, where he saw the whole process of papermaking. After touring the East and West mills the Duke proceeded to the converting factory and mill of Kimberley-Clark, Ltd., an associate company of the Reed Paper Group, and formally opened the new cellulose wadding mill by starting one of the first reels, to be produced by the mill, on its way to the conversion factory. Plans for the new mill were prepared in 1954 to meet the expanding demands for cellulose products. The mill block, of reinforced concrete, has a length of 250ft, a breadth of 150ft and a height of 50ft, and has two floors to take the auxiliary machinery and the mill, the latter being housed on the first floor. There is a complete system of air conditioning throughout and in addition the conversion factory is pressurised to prevent ingress of dust and steam.

The new cellulose wadding mill has an overall length of 120ft, an electronically controlled drive, and has a potential production speed of 3000ft per minute so that the present output of conversion products will be doubled. The floor space provided is sufficient to permit the installation of a second mill. Pulp preparation, wadding manufacture, reeling and slitting are carried out in a single building, with provision for mechanical handling of the material to the conversion plant, where the machines incorporate a high degree of automation.

Beyer-Garratt Locomotives for Rhodesia Railways

About two years ago, Beyer Peacock and Co., Ltd., completed an order for fifteen Beyer-Garratt class "20" articulated locomotives for the Rhodesia Railways, and shortly after received an order for a further forty-six similar locomotives with a few minor modifications. Last week a party of guests at the Gorton Works of the builder were given an opportunity to see one of the new locomotives under steam and a number of others in course of construction. These new "20A" class locomotives for the Rhodesia Railways 3ft 6in gauge have a 4–8–2+2–8–4 wheel arrangement and each weighs some 225 tons in working order, giving a designed axle load of 17 tons. They have a boiler pressure of 200 lb per square inch and, at 85 per cent pressure, the tractive effort is 69,330 lb. The principal differences between these locomotives and others previously supplied are in the outer bogie wheels, which are 2ft 9in diameter, as compared with 2ft 4½in, and the coal capacity which has been increased by ½ ton to 14½ tons.

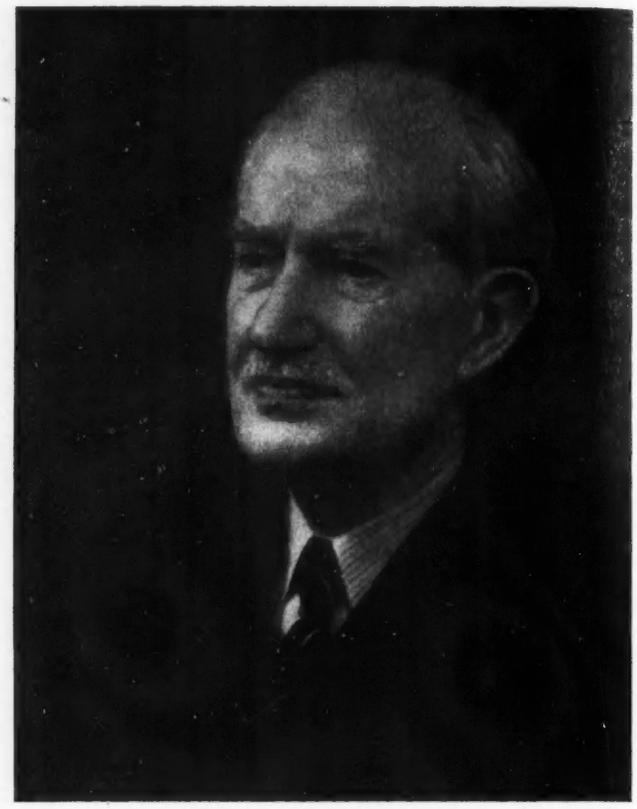
When this order is completed, the Rhodesia Railways will have purchased a total of 250 Beyer-Garratt locomotives. It was pointed out by Sir Gilbert Rennie, during the visit to the works, that these locomotives will eventually be responsible for some 70 per cent of the total tractive effort of the country's railway system.

Dr. G. E. Foxwell, C.B.E.

We note with regret the death of Dr. Geoffrey Edwin Foxwell, which occurred suddenly at his home at Ashtead, Surrey, last Friday. For many years he had occupied a prominent place in the science of fuel technology.

Dr. Foxwell, who was sixty-four, was born at Hinckley, Leicestershire, and was educated at the Hinckley Grammar School and All Saints School, Bloxham. He began his professional career in the chemical section of the Koppers Coke Oven Company, Ltd., and later became the company's chief technical officer. Before taking up this latter appointment, however, Dr. Foxwell spent some time with the former Gas Light and Coke Company, in London, and on the formation of its research department in 1924, was the company's senior research chemist for a year or so. Meanwhile, between 1916 and 1924, he had gained the B.Sc., M.Sc. and D.Sc. degrees of the University of London. From 1933 onwards Dr. Foxwell was engaged principally on consulting work, and during the second world war he served as technical adviser to the Ministry of Fuel and Power. His more recent public service in the field of fuel technology included membership of the Beaver committee on air pollution. Dr. Foxwell was one of the founder members of the Institute of Fuel, was elected a Fellow in 1928, and was president from 1951 to 1953. He was also chairman of the British Chemical Plant Manufacturers' Association. Dr. Foxwell was awarded the C.B.E. in 1951.

Sir Murdoch MacDonald



We record with regret the death of Sir Murdoch MacDonald, which occurred at his home at Nairn, Inverness, on April 24. Sir Murdoch, who was approaching his ninety-first birthday, had spent a distinguished career in civil engineering, which extended well over sixty years. In fact, it could not be said that he had retired, for until comparatively recently he had taken an active part in the design of a new bridge over the Ness in his native town of Inverness.

Sir Murdoch, who was the son of Mr. Roderick MacDonald, received his general education at Farraline Park School, Inverness. His apprenticeship as an engineer was served with the former Highland Railway Company, and after its completion he spent some years as an assistant engineer on various railway construction projects in Northern Scotland. Among them, there was the building of the Black Isle line between 1890 and 1894, and the widening of the main line between Dalnaspidal and Blair Athol. Many years afterwards, Sir Murdoch recalled that this railway work in the early part of his career included the design and erection of an earthen dam, about 35ft high at its maximum point, across a small stream as well as the design of a small power station driven from it.

In 1898, Sir Benjamin Baker invited Sir Murdoch to go to Egypt to act as assistant engineer to Sir Maurice Fitzmaurice, who was then engaged on the construction of the first Aswan Dam. Four years previously, a technical commission, on which Sir Benjamin Baker served, had been appointed by the Egyptian Government to examine different projects for the storage of Nile water. The commission reported in favour of the construction of the Aswan Dam, and selected an alignment which, it decided, should be straight from bank to bank. At the time, it may be recalled, there was a good deal of controversy as to the probable effect of the water issuing from the sluices on the rock downstream. Sir Murdoch's appointment as an assistant engineer for the building of the dam marked the beginning of a term of service in Egypt which continued for twenty-three years. When the first heightening of the Aswan Dam was undertaken between 1908 and 1912, he was director-general of irrigation for the Egyptian Government. Subsequently he became Under Secretary of State for Public Works, and finally adviser to the Minister of Public Works.

For most of those years in Egypt, Sir Murdoch's principal work was, of course, concerned with the Aswan Dam. The original dam was completed in 1902, and provided water-storage capacity, additional to the normal river supply, for the requirements of Egyptian agriculture as it stood. Furthermore, the reservoir was capable of holding a summer water supply for such land as might reasonably be expected to be converted to summer irrigation in the immediate future. But by 1905 it appeared that Egypt was experiencing a cycle of low years in regard to the volume of water passing down the river during the summer. The Government was thus very soon faced with the problem of finding additional storage room to meet possible demands for the existing area, as well as making adequate provision for future extension. A scheme for thickening and heightening the existing Aswan Dam was prepared by Sir Benjamin Baker, and a great deal of the work involved was undertaken by Sir Murdoch. The project was brought to fulfilment principally under his direction, and the "first heightening" was completed in 1912.

There were, however, several other projects initiated by Sir Murdoch during his years of service with the Egyptian Government. He was responsible for the planning and completion of overall drainage schemes for lower Egypt which finally dealt with about 3,000,000 acres. He also designed the Sennar Dam on the Blue Nile, and put into operation the first stages of the Gezira irrigation schemes for the conversion of virgin land in the Sudan for cotton growing. In addition, Sir Murdoch designed the Gebel Aulia Dam, which, though built in the Sudan, provides 4000 million cubic metres of water annually for irrigation in Egypt. Then he designed and constructed the head works of the Menufia Canal, the Esna Barrage—one of the largest works on the Main Nile—and effected large-scale improvements to Alexandria Harbour. But forty years or so ago, the propagation of many of these schemes for the development of Egypt aroused much controversy. One expert commission after another was set up to examine the projects and investigate the criticisms of them, and it was in this connection that Sir Murdoch prepared a detailed report entitled *Nile Control*. To this day it is looked upon as a valuable guide to the effective use of the waters of the Nile.

Sir Murdoch retired from the Egyptian Government service in 1921 and on returning to this country established the firm of consulting engineers which practises under the name of Sir M. MacDonald and Partners. But he did not relinquish his work on Egyptian irrigation schemes. The firm was invited to submit proposals for a second heightening of the Aswan Dam, and the work was carried out between 1929 and 1933. On its completion, Sir Murdoch received a message of congratulation from the Egyptian Government. At about the same time, Sir Murdoch was responsible for work undertaken to strengthen the Esna Barrage, and he also advised on various schemes for land drainage and irrigation in Greece and Portugal. At the end of the second world war he was again consulted by the Government of Egypt about the Aswan Dam, and submitted a report advising that a third heightening was practicable. Between 1951 and 1953, Sir Murdoch was engaged on the design of four new schemes, for the Egyptian Government, involving barrages and storage reservoirs on the Nile. Twice during that period, undeterred by advancing years, he visited Egypt to discuss these works.

In recent years Sir Murdoch's principal work in this country was associated with some of the North of Scotland Hydro-Electric Board's schemes, and with the Great Ouse flood protection scheme. This latter work was first considered early in 1938 following serious flooding in the Fens. Several proposals were put forward, and Sir Murdoch was asked to formulate a protection scheme in conjunction with the River Great Ouse Catchment Board. Detailed surveys were made to determine the practicability of the works involved, and a report dealing with the whole problem was presented to the Board. This report was printed in The Engineer of March 7 and 14, 1941. It was impossible, of course, on account of the war, for the scheme to be proceeded with immediately, but further serious flooding emphasised the urgency. About three years ago the work was started in earnest under the direction of Sir Murdoch's firm, and when completed will effect tremendous improvement in the drainage of the Great Ouse basin.

The works which we have touched upon briefly here indicate the foremost of Sir Murdoch MacDonald's activities during his long career as a civil engineer. But any record of that career would be incomplete without a reference to his services in other spheres. Sir Murdoch was elected an associate member of the Institution of Civil Engineers in 1892, and a full member in 1909. He became president of the Institution in 1932, and in his presidential address, delivered in November of that year, presented a most informative survey of the irrigation and other work with which he was so intimately associated in Egypt. Prior to that, he had presented to the Institution two papers dealing with various aspects of the work on the Aswan Dam, and for each of them he was awarded a Telford gold medal. Sir Murdoch also gave much attention to political matters, serving as Member of Parliament for Inverness from 1922 to 1950. He was created K.C.M.G. in 1914, was awarded the honour of C.B. in 1917, and in 1930 received the Freedom of the Royal Burgh of Inverness.

Damping Capacity

By J. V. HARDING, B.Sc., Ph.D., F.I.M.

Damping capacity measurements are sometimes used as a means of indicating the physical condition of materials, but in this article we are concerned only with the application of this property in engineering and with particular reference to cast irons. No full review is made of the great amount of literature on the subject, as this has been done very thoroughly by other writers, e.g. Thompson[1] and Linacre.[2] Reference should also be made to the annotated bibliography to the papers by Hatfield, Rotherham and others.[3,4] On an engineering scale, damping capacity changes of a small magnitude are of little interest, but the very large differences in different materials and at different stress levels have an important effect, and should be taken into account more than they are.

Damping Capacity and Plastic Behaviour

DAMPING capacity may be expressed as energy absorbed per cycle of alternating stress (e.g. in inch-pound per cubic inch) or as percentage loss of energy per cycle. Damping capacity is given by the area of the stress-strain loop during cycling, and the ideal method of measuring it would be to plot the loop under the desired speed and stress cycle. Examples of this technique are given by Morkovin and Moore,[5] and by Forrest and Tapsell.[6] It is, however, usually sought to obtain the required information by simpler means; it is, therefore, instructive to consider the relationship of damping capacity to more familiar properties, and to compare the significance of values obtained by various methods.

The static stress-strain curve is known for most materials, and has a bearing on damping capacity and other dynamic properties. If the static stress-strain loop were followed during cycling at speeds of interest, it would be possible to make an estimate of damping capacity from the stress-strain curve, assuming that all curvature is due to permanent strain and that the unloading line is elastic. With cast iron, the stress-strain curve shows a plastic component at lowest stresses, and in addition the elastic portion of the curve shows slight curvature.[7,8] The loop area, however, still depends on plastic strain, as the return line may be assumed to be parallel to the elastic line.

In a qualitative manner, the existence of plastic deformation at low stress ties up conveniently with the observed high damping capacity of cast irons at low stresses, but there are some indications that cast irons (at least, those of high strength) behave more nearly elastically at low stress under cyclic than under static stress. This is illustrated in Fig. 1, which compares a static stress-strain curve given by Lloyd and Harding[7] with a dynamic stress-strain curve determined, at the N.P.L., by the method of Forrest and Tapsell[8] at 1900 cycles per minute. Lazan[9,10] and Forrest and Tapsell have shown that most materials behave differently under dynamic stress, so that for more than rough comparisons it is necessary for the dynamic stress-strain curve to be determined, if damping capacities are to be determined in this way. Some examples of estimations will be given in the next section.

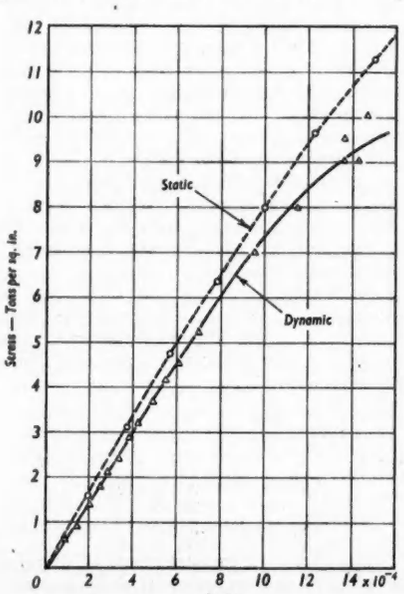


Fig. 1—Static and dynamic stress strain curves, "Meehanite" GA

The curves in Fig. 1, were obtained on separate batches of material, but both were of the same type of unalloyed iron ("Meehanite" GA) having tensile strengths of 25 tons and 24 tons per square inch, and made to the following property specification :—

Tensile strength	22·5 tons/sq. in min.
Modulus of elasticity	20×10^6 lb/sq. in.
Transverse modulus of rupture	40 tons/sq. in.
Fatigue strength (bending)	10 tons/sq. in.
Izod impact (0·798in dia. unnotched bar)	25ft-lb.
Torsional strength (0·75in dia. bar, 14·5 in long)	60,000 lb/sq. in.
Brinell hardness	220

The increase in curvature at about ±6 tons per square inch is in line with the observations of Lazan and of Forrest and Tapsell on steels and other materials, and was named by Lazan the "cyclic stress sensitivity limit," above which damping capacity increases with the number of cycles applied, until a steady state is reached. This stress range is normally about 80 per cent of the fatigue limit of the material, but in this case the fatigue limit was approximately ±9 tons per square inch. The more elastic behaviour at low stress under cyclic stressing is also in line with Lazan's observation that at low stress damping capacity may fall during cycling. The dynamic stress-strain curve is the result of measurements after running up to maximum stress, and during continued cycling at 1900 cycles per minute, until the specimen either settles down or fails.

The static stress-strain curve, on the other hand, is determined on virgin material. Undoubtedly during the initial cycles work-hardening occurs, and plastic deformation falls to quite a low level. The static test was also determined at a low speed, especially compared with the rapid loading occurring in alternating stresses. Lloyd[11] has observed that the tensile strength of cast iron falls somewhat with slower loading, and it may be that the plastic deformation occurring at low stress requires an appreciable time for completion and is also responsible for this slight fall in tensile strength. Curvature of the stress-strain curve confers ability to redistribute stresses at working stress levels, and is a useful property. It is often also associated with low notch sensitivity, ability to withstand dynamic overload for short periods without damage, and ability to benefit from dynamic understressing.

Cast irons are generally supposed to possess a high damping capacity even at low stresses, and indeed many of their successful applications are attributed to this property. Normal measurements of decaying vibrations on virgin material also confirm this supposition. The present work, as well as other results discussed here, however, tend to show that continued cycling at low stress brings about a more nearly elastic condition, akin to that of steel. The characteristic high damping capacity of cast iron does not appear to be exhibited under these conditions until quite high stresses are applied.

Comparison of Various Methods of Measuring Damping Capacity

Methods of measuring damping capacity may be divided according to whether the test involves sustained or free vibrations. In both cases various methods may be used to measure the energy dissipated, such as measurement of amplitudes and stresses or of heat dissipated. Undoubtedly sustained vibrations present a more realistic picture of service behaviour, but since their measurement is more difficult, it is advisable to consider what significance may be attached to simpler methods, i.e. how far they may be expected to give data corresponding to that obtained under simulated service conditions. In this section results obtained by three different methods on similar material (again "Meehanite" GA) will be compared.

Decay of Free Torsional Vibrations.—For these tests the instrument made by the Cambridge Instrument Company, Ltd., was used. This method measures specific damping capacity only (energy loss÷total energy at peak of cycle), since it is virtually impossible to estimate the actual quantity of energy dissipated per cycle. The assumption is made that at successive peaks energy is proportional to (amplitude)^2, which is an approximation that becomes less accurate as damping capacity increases. The formula used was as follows :—

$$P = \text{specific damping capacity per cent}$$

$$= \frac{A^2 - B^2}{A^2} \times 100$$

$$= \text{approx. } 2\frac{A-B}{A} \times 100$$

where A and B are successive full cycle amplitudes.

The values of A and B are read off a smoothed curve of amplitude versus vibration number, in order to reduce the inaccuracies of individual measurements of amplitude. A curve is produced of specific damping capacity versus shear strain on the surface. As the stresses are torsional, the damping capacity measured is a total value for a section over which stresses and strains vary at any given instant, and since the elastic limit is exceeded in some part of the specimen, accurate calculation of the surface damping (the value required for correspondence with surface strain) is not simple.

The following formula, given by Föppl,[12] was used for conversion in these tests, since comparison with other methods was required:

$$D_o = D_m + \frac{dD_m}{dL} \cdot \frac{L}{2}$$

Where

D_0 = surface damping capacity
D_m = mean damping capacity
L = surface strain

For comparison of damping capacity with stress, it was necessary to use a fixed value for modulus of rigidity ($G = 8 \times 10^6$ lb per square inch) in the absence of data for the dynamic modulus.

It should also be pointed out that these vibrational decay tests were made on virgin specimens, which was done in order to make these tests as simple as possible. However, as already mentioned, previous cycling above a certain critical stress will gradually increase damping capacity and reduce the modulus to a considerable degree, even at stresses well below the fatigue limit.

Estimation from Dynamic Stress-Strain Curve.—The curve shown in Fig. 1 was used for approximate estimations of damping capacity by : (*i*) assuming an unloading line parallel to the stress-strain curve at the origin ; (*ii*) assuming the area between the stress-strain curve and the unloading line to be one-quarter of the total loop area.

See also Lazan (1950) for alternative method.

Resonant Vibrations.—Results given by Robertson and Yorgiadis[13,14] for damping capacity under sustained torsional vibration are included for comparison. These tests were made on an apparatus developed by Lazan in which the specimen is subjected to resonant vibrations in an apparatus of low damping capacity, and the energy input is calculated from the amplitudes of stress and strain. Robertson and Yorgiadis noted a correlation between shear and direct stress values of damping capacity when the shear stress was multiplied by a value K, which was between 0·48 and 0·60 ; Föppl[15] gave values between 0·53 and 0·60 ; this function might correspond with the value 0·500 for equal volume change, or 0·577 for equal distortion energy, under the two types of stress. These results are given as damping capacity in inch-pounds per cubic inch per cycle.

Results obtained by these three methods are given in Table I, and shown in Figs. 2

Type of stress	Stress, ±tons per square inch	Damping capacity,[1] inch-pounds per cubic inch per cycle	Specific damping capacity, per cent	Source
Sustained shear	1·78	0·083	—	Yorgiadis[14]
	2·68	0·28	—	
	3·57	0·66	—	
	4·46	1·3	—	
	6·70	4·4	—	
	8·92	10·4	—	
Sustained tension - compression	6·5	0·54	7·6	Dynamic stress-strain curve
	7·55	2·92	29·2	
	8·5	6·28	46·0	
	8·9	9·7	62·0	
	9·6	16·8	86·5	
Free torsional vibration (shear)	0·54	—	2·32	Tests on Cambridge type instrument
	1·07	—	2·90	
	2·14	—	3·80	
	3·21	—	4·50	
	4·28	—	5·30	
	5·35	—	6·00	
	6·42	—	6·85	
	7·60	—	9·05	
	8·56	—	13·10	
	9·08	—	20·5	

and 3 as straight plots of damping capacity versus stress. The methods compared here are of too diverse a nature to allow any strict comparison to be made, but if the simple theories already mentioned are taken into consideration, a fair qualitative agreement may be found for these various tests.

In Fig. 2 Yorgiadis' results in shear are compared with present results in tension-compression. At low stresses, similar damping capacity values hold for shear stresses about half the direct stress, but the two curves

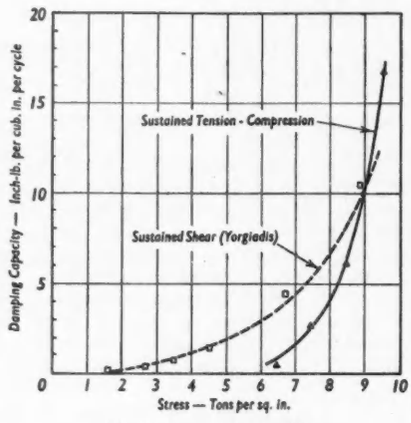

Damping Capacity — Inch-lb. per cub. in. per cycle
Sustained Tension - Compression
Sustained Shear (Yorgiadis)
Stress — Tons per sq. in.

Fig. 2—Damping capacities

approach as stress increases and appear to meet in the neighbourhood of the fatigue strength, which in this material is similiar in torsion and direct stress. In Fig. 3 the torsional free vibrational results are compared with results under sustained tension-compression. At low stresses, again it may be inferred that shear stress has resulted in a larger damping capacity, but as the critical stress is passed, the direct stress figures rise rapidly, due to their being taken on material cycled many times as against the virgin material in shear. These figures show the kind of comparison to be expected by the different testing methods, and indicate that

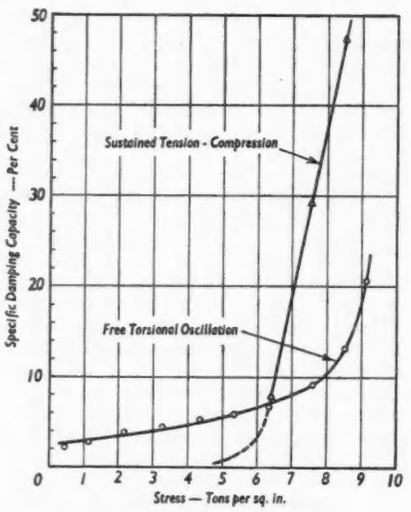


Fig. 3—Specific damping capacities

the method of decay of free vibrations, though useful for obtaining data easily, is in fact more in the nature of a static than a dynamic test. Even subjecting the specimen to a number of cycles of free oscillation does not entirely remedy this owing to the continual variation in stress.

Nevertheless, the author considers that the free oscillation type of test is valuable for comparing different materials and that an understanding of how a given class of materials will behave under sustained cyclic stresses will greatly enhance the value of the data obtained.

The Utilisation of Damping Capacity of Materials in Engineering

It is doubtful whether damping capacity values have ever been used in design in a quantitative manner, although undoubtedly damping capacity of materials does play an important part in selection and in service performance. Obviously one cannot use it as a main criterion in selection, unless other properties are not very important, which does not often occur in engineering. Cast iron is suitable for machine beds because of its good compressive strength, stability, and ease of producing the shapes required, and its damping capacity is an added advantage in so far as it reduces vibrational movement between the tool and workpiece, cuts down noise and vibrational movement generally, and thus assists in reducing wear over long periods. There are many similar applications where this property is of great but not easily assessed value. Its very great success in a number of dynamic applications is undoubtedly due to a combination of good fatigue strength with high damping capacity, together with a certain amount of resistance to shock which is the distinguishing feature of the " high-duty iron." Such applications are crankshafts, couplings and tool bodies. In the latter case, a much-improved machined finish has been claimed, particularly when the tool has been used on welded structures, on account of the damping out of vibrations, so that in this case damping capacity may become so important as to allow a degree of sacrifice of other mechanical properties.

A further interesting case of damping capacity becoming as important as strength was recently reported to the author, in which steel couplings on a piece of foundry equipment subject to heavy vibrations failed repeatedly. In desperation the foundry cast some couplings in 22·5 tons per square inch iron, and with this no failures occurred. The use of cast iron gears as a means of reducing noise is well known, but less attention has been given to the usefulness of damping capacity as a mechanical property of the material in this application. Obviously one would not attempt to use a cast iron in places where a high degree of static ductility and shock resistance were needed. If damping were also required, one would attempt to introduce it in joints and bearings, or by use of a more expensive material such as stainless iron, if otherwise suitable.

On the other hand, the properties of ductility and shock resistance, which in most static applications are precautions against stresses getting out of control, are of less value under regulated dynamic stresses since failures are non-ductile. Materials of high damping capacity and low dynamic modulus possess what Lazan calls " dynamic ductility," which enables a degree of overstress to be better distributed over the material composing the member than in more rigid materials. Undoubtedly this property, together with low resonance amplification, plays an important part in the success of high-duty cast iron crankshafts.

Considerable attention has been given to the question of stresses developed in resonance. Some interesting data has been given by Yorgiadis, who has expressed in a quantitative manner the value of damping capacity in preventing the build up of stresses at resonance. Yorgiadis calculated the stress build up at resonance, in uniformly stressed material under tension-compression, from the relationship :

$$f_m = \frac{D_m E}{\pi S_m}$$

where

f_m = excitation stress applied
S_m = stress developed
D_m = damping capacity.

From his own measurements of damping capacity of various materials under sustained vibrations, Yorgiadis prepared charts of stress applied versus stress developed, up to the fatigue strength of the material concerned.

Thus the applied excitation stresses needed to produce fatigue failure were approximately as follows :—

Material	"Resonance strength" or excitation stress to produce fatigue failure Lb/sq. in
Cast iron (Meehanite GA)	850
Steel SAE 1025	650
Steel SAE 4130	650
Compressed plywood	350
Magnesium alloy J-1	300
Plexiglass	150
Dural 17S-T	55

The appearance of the cast iron at the head of this table does give quantitative expression to a virtue of which exponents of this material have been aware for some time, i.e. its good combination of fatigue and damping. It is, of course, improbable in a well-designed machine that a member will resonate long enough to produce fatigue failure, and, as already mentioned, other considerations often override the damping capacity of the material. Nevertheless, it is an aspect of materials engineering that could well receive more attention.

ACKNOWLEDGMENTS

The author is grateful to the Director, National Physical Laboratory, for permission to publish results from a report issued to the International Meehanite Research Institute, and to Mr. P. G. Forrest, of the N.P.L., for carrying out tests and for helpful advice. He also acknowledges the assistance given by Mr. W. McHutchison, of Royal Technical College, Glasgow, in carrying out further tests. Thanks are due to the International Meehanite Metal Company, Ltd., for permission to publish this article.

REFERENCES

[1] Thompson, F. C., British Non-Ferrous Metals Research Association Research Report R.R.A. 657, 1944.
[2] Linscre, E., *Iron and Steel*, May, June and August, 1950.
[3] Hatfield, W. H., Stanfield, G., and Rotherham, L., *Trans. N.E. Coast Inst. Eng. and Shipbuilders*, 58, 1942.
[4] Hatfield, W. H., Rotherham, L., and Harvey, E. M. A., *Ibid.*, 60, 1942.
[5] Morkovip, D., and Moore, H. F., *Trans. A.S.T.M.*, Vol. 44, 1944.
[6] Forrest, P. G., and Tapsell, H. J., *Proc. Inst. Mech. Engrs.*, 1954.
[7] Lloyd, H. K., and Harding, J. V., not yet published.
[8] Grant., J. W., *Brit. Cast Iron Research Assoc. Journal of Res. and Dev.*, Vol. 3, No. 11, April, 1951.
[9] Lazan, B. J., *Trans. A.S.M.E.*, Vol. 65, 1947.
[10] Lazan, B. J., *Trans. A.S.M.E.*, Vol. 42, 1950.
[11] Lloyd, H. K., *Metal Treatment*, July, 1956.
[12] Föppl, O., Becker, E., and von Heydekampf, G. S., *Dauerprufung der Werkstoffe*, Berlin, 1929.
[13] Roberton, J. M., and Yorgiadis, A. J., *Journal of Applied Mechanics* (A.S.M.E.), September, 1946.
[14] Yorgiadis, A., *Product Engineering*, November, 1954.
[15] Föppl, O., *Journal Iron and Steel Inst.*, 1936, Vol. 134.

Trends in Canadian Railway Equipment

(Contributed)

TO the railway-minded traveller returning to Canada after an absence of about ten years (a long period, having regard to the rapidity of development in that great country) the changes are indeed spectacular. Ten years ago there were in Canada 4387 coal-burning steam locomotives, no oil-burning steam locomotives and twenty-nine diesel-electric locomotives. Before the end of 1953 as many as 956 diesel-electric locomotives had been introduced and the total numbers of coal burning steam locomotives had fallen to 3162. There were, moreover, 667 oil-burning steam locomotives and 33 electric locomotives, so that of a total stock of 4818 locomotives, 20 per cent were of diesel-electric type. The last order for a steam locomotive for any Canadian railway (a C.P.R. 2–10–4) was placed in 1949. Since then an official announcement has been made to the effect that no more steam locomotives will be ordered. To-day, it is estimated that 30 per cent of the locomotives in use are diesel-electric, much of the manufacturing work involved in their supply being carried out in Canada. For example, General Motors have a locomotive assembling plant at London, Ontario, the oil engines, electric generators and traction motors being supplied from La Grange. At Montreal, diesel-electric locomotives are built by the Montreal Locomotive Works, the engines (of ALCO design) being supplied by Dominion Engineering Works, Montreal and the electric equipment by The Canadian General Electric Company, Peterborough, Ontario. At Kingston, Ontario, the Canadian Locomotive Company build diesel-electric locomotives powered by Fairbanks-Morse engines. Air compressors and braking equipment are supplied by The Canadian Westinghouse Company, Hamilton, Ontario. It should be noted that the mileage of single railway track in Canada is 43,163 (1953 figures). Adding second track, industrial track and sidings, the 1953 total was 60,776.

Very interesting to the visitor are the particulars which, issued by the Canadian Pacific Railway, describe the equipment of the magnificent trains recently put into operation between Montreal and Toronto and Vancouver. "You'll travel in comfort" they affirm, "aboard Canadian Pacific's new all-stainless-steel streamlined train . . . on the world's longest 'dome' ride . . . in less than three days." Details are given of the Scenic Dome observation lounge cars, de luxe sleeping cars, scenic dome coffee-shop coaches and many other attractive features including "the latest in sleeping car comfort; reserved adjustable seats with full length leg rests in streamlined coaches; de luxe dining room cars; table service at modest prices in skyline coffee shops and smooth, sleek diesel operation all the way." Specially publicised are the "scenic dome cars, these high-level, all-round-vision, air-conditioned, glare-proofed, vantage points, the only 'dome' cars in Canada." The new scenic-dome stainless-steel streamliner "The Canadian" was put into service by the Canadian Pacific Railway on April 24, 1955, six trains each consisting of fourteen cars being required in order to maintain the daily schedules in both directions. The autumn 1955 schedule of "The Canadian" allows 70 h 20 min for the journey from Vancouver to Montreal, via Banff, Medicine Hat, Regina, Winnipeg, Port Arthur, Sudbury and Ottawa, a total distance of 2881·2 miles. Westbound, the time allowed (Montreal-Vancouver) is 71 h 10 min. While Vancouver is at an altitude of 14ft and Montreal at 109ft, the line reaches (at Lake Louise, 525 miles from Vancouver) a summit level of 5050ft and at Banff (34·7 miles from Lake Louise) the altitude is still as much as 4534ft. This train (and "The Dominion") are described as "Canada's only 'domes,' diesel streamliners all the way east and west." On the Canadian National Railways, the introduction (April 1955) of the "Super Continental" reduced by up to 14 h the previous coast to coast schedules of this line. From Vancouver to Montreal the booked time is 71 h 20 min, the distance via Edmonton, Saskatoon, Winnipeg, Capreol and Ottawa being 2924·2 miles. On this route the summit altitude is 3717ft, reached at Yellowhead, B.C., 511·5 miles from Vancouver. It is to be noted that in a distance of rather more than 154 miles (Morey to Bickerdike) as many as twenty-three stations are situated at altitudes in excess of 3000ft. That the Canadian trans-continental trains should have "hung up two records between them: the longest dome-car and diesel-locomotive runs in the world" is a claim very creditable to the Canadian railways. As for the diesel-electric locomotives employed on these trans-continental trains, they are usually hauled by General Motors locomotives.

Among other developments which will surely be noted by a railwayman visiting Canada is the extent to which the "road switcher" locomotive is used for hauling important passenger trains. Being equipped with the same engine and the same electrical items, the "road switcher" is regarded as possessing the same characteristics as the "road freight" locomotives, while being more versatile. With an engine rating of 1750 b.h.p. the "road switcher" is geared for a speed (in Canada) of up to 90 m.p.h. The present writer was rather surprised when, standing recently at the outer end of the platform area in Dearborn Street Station, Chicago, just prior to the departure of "The Maple Leaf" (train No. 20) for Toronto, he noticed backing down on to the train two locomotives which he took to be "yard switchers." They were, in fact, General Motors "road switchers," i.e. general-purpose diesel-electric locomotives with engines of 1750 h.p. They hauled the 480-ton train from Chicago to Port Huron (Michigan), a distance of 333 miles, arriving exactly on time. The stops on this train are frequent and for some unascertained reason the actual departure time was 10.11.15 a.m. instead of the booked 10.00.00. There were several unbooked delays *en route*, notably at Durand, Michigan. The fact that so considerable an amount of time could be made up was manifestly due to the high speed maintained between station stops, much of the intermediate distance being covered at a speed of 80 m.p.h. Moreover, the acceleration given by the two "road switchers" was notably rapid. It is to be mentioned that while the locomotives went through from Chicago to Port Huron, the crew was changed at Battle Creek, Michigan, 177 miles from Chicago.

Canadian enginemen speak well of these "road switchers" and their use for general purposes appears to be rapidly extending. Travelling on the 8.05 a.m. (train No. 721) from Toronto to Buffalo, the writer noticed that while the train left Union Station, Toronto, with two Canadian Pacific diesel-electric locomotives of General Motors cab type (popularly referred to as "covered wagons"), these were replaced at Hamilton, Ontario, by two "GP–9" General Motors "road switchers" (popularly known as "geeps"), the particular pair being the first of the type delivered from the London (Ontario) works of General Motors. Each has an engine of 1750 b.h.p. and once more the quick acceleration and high speed between station stops was a conspicuous feature of the journey. The "geeps"—belonging to the Toronto, Hamilton and Buffalo Railway—hauled the train from Hamilton to Buffalo, which includes a stretch (Welland to Buffalo) owned by the New York Central. Arrival at Buffalo (Central Terminal) was just 1 min before time.

Referring to fast railcars, this type of equipment is becoming well represented on Canadian routes deemed favourable to their

operation. For example, the "Dayliner" railcar (train No. 604), which leaves Toronto (Union Station) at 11.00 a.m., is booked to reach Peterboro at 12.20 p.m. There is an intermediate stop at Leaside (11.10 a.m.) and a further stop can be made on signal given at Agincourt. The inclusive time Toronto to Peterboro is 80 min and as the distance is 76·5 miles, the inclusive average speed is 57·38 m.p.h. There are other fast services by "RDCs" (rail diesel cars), the vehicles used being built with air-conditioned, stainless steel bodies propelled by General Motors engines through mechanical transmission.

Not to be lost sight of in connection with passenger transportation in Canada is the long-distance bus, an example of which is found in the "Scenicruiser Express," operating between Toronto and New York with two services daily each way. The buses employed have air suspension springs replacing the conventional steel springs and are air-conditioned, complete toilet facilities being also provided. Departure times from Toronto (bus terminal) are at 8.00 p.m. and 8.00 a.m. respectively, the bus leaving at 8.00 p.m. being due in New York (West Thirty-Fourth Street) at 11.15 a.m. the following morning, the route being via the Queen Elizabeth Way and the New York State "Thruway" (Buffalo, Rochester, Syracuse, Utica, Albany). The day bus leaves Toronto at 8.00 a.m. and is due to reach New York at 11.30 p.m. Returning from New York the buses leave West Thirty-Fourth Street at 8.30 a.m. and 8.30 p.m., arrival at Toronto being at 11.59 p.m. and 11.30 a.m. respectively. It will be noted that the times occupied on the Toronto–New York journeys are 15 h 15 min on the night service and 15 h 30 min on the day service. Returning from New York the times are 15 h (night journey) and 15 h 29 min (day journey). These times include rest and lunch stops. According to the October, 1955 railway timetable, the fastest Toronto–New York timing over the Canadian Pacific and New York Central Railroads via Buffalo is given by "The Ontarian," a sleeping-car train leaving Toronto (Union Station) at 8.40 p.m., and due to reach New York (Grand Central Terminus) at 8.15 a.m. the next morning, the total distance by rail being 538 miles. Since the inclusive time is 11 h 35 min, the inclusive average speed is 46·45 m.p.h. By the night bus service from New York the time occupied is 15 h, so that the difference in favour of the train is 3 h 25 min. By the day train booked to leave Toronto at 8.05 a.m. and to arrive at New York (Grand Central) at 8.10 p.m., the time occupied is 12 h 5 min, or just 2 h 55 min less than the fastest time by bus.

If intense competition from the aeroplane, the private automobile and the road bus can act as a stimulant to the courage and enterprise of railwaymen, the Canadian railways should be able—possessing as they do the valuable backing of their expanding freight traffic—to tackle with increasing vigour the problems presented by the resuscitation of the passenger business.

Strength Calculations of Bolted Joints

By M. BOOMSMA, A.M.I.E.Aust.*

The load capacity of bolted joints is limited either by the fatigue strength or the yield point of the bolts. When the latter applies, suitable tightening presumed, the stiffness factor ratio of bolts and abutments has no effect on the capacity of the joint, which is a maximum. The range of this desirable condition is discussed.

IT is of importance to the design draughtsman and the engineering student that they clearly understand the range of some calculations because this will save them much time. In the following, only calculations appertaining to the load capacity of bolted joints will be considered. Literature is, as a rule, vague on this subject and where more detailed information is given it is often of little practical help. Such calculations are hampered by the fact that the initial load in bolts, even with torque wrenches, usually is a very uncertain quantity. The same applies to the stiffness factor ratio of bolts and abutments. Therefore in such cases it is helpful to know what to calculate and what not to calculate.

The following is a repetition of well-known basic theory. However, it will be shown that in many cases the method of calculation, by a suitable approach, can be made more direct because certain factors need not be considered.

The three basic conditions to be satisfied in any bolted joint are :—

(*a*) The bolt load should preferably not exceed the yield point.

(*b*) The joint must not open.

(*c*) The endurance limit must not be exceeded.

Fig. 1 shows an endurance diagram. The line *AB*, indicating the yield point, has an inclination of 45 deg. The ordinate indicates the endurance limit under fully reversed loading and the abscissa the static strength of the material or part. On the ordinate is plotted the stress amplitude and on the abscissa the average steady stress. The

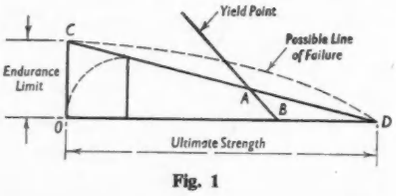


Fig. 1

dotted curve represents a possible line of failure ; the straight line *CD* is therefore a safe approximation. When only the endurance limit for a load cycle from zero to a maximum is known, proceed as shown in the diagram. The average steady stress then equals the stress amplitude.

Fig. 2 shows the load-distribution diagram of a bolted joint. Tan $\alpha=C_a$ is the stiffness factor of the abutments, tan $\beta=C_b$ that of the bolt. With one limitation[1] it follows from the diagram that the load amplitude in the bolt is

$$P_{am}=\frac{0\cdot5P_z}{1+\frac{C_a}{C_b}}$$

where P_z is the external load applied to the joint. When P_i is the initial load produced by tightening, the total bolt load is

$$P_t=P_i+2P_{am}=P_i+P_d$$

P_d is the load fluctuation (dynamic bolt load).

Considering now the aforementioned conditions and selecting the appropriate initial loads, the maximum external load that can

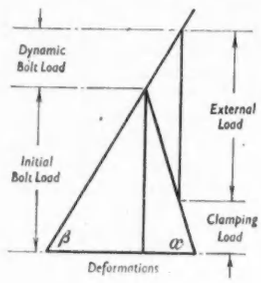


Fig. 2

be applied to a joint, irrespective of its stiffness factor ratio providing it is within a certain range, equals the yield strength of the bolts. Or, in terms of bolt stress $S_{z\,max}=S_y$. This extreme case is shown in Fig. 3. At first, no factor of safety will be applied in the following numerical example.

The material in a bolt tests 63,000 lb per square inch for ultimate tensile strength and 35,000 lb per square inch for yield point.† The endurance limit of the bolt (Whitworth or Unified) for a load cycle from zero to a maximum is about 20,000 lb per square inch.[3] The ultimate stress amplitude and the corresponding average steady stress therefore are 10,000 lb per square inch.

A stress amplitude limited by the line *AB*

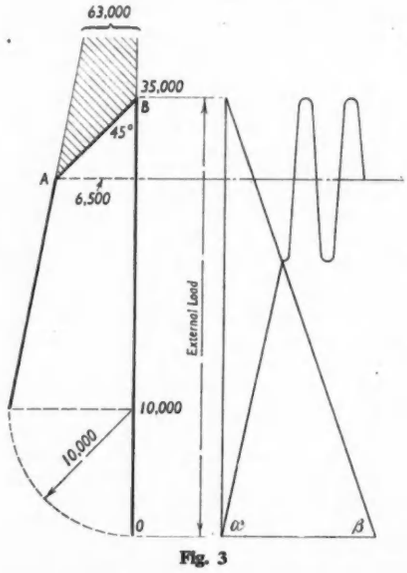


Fig. 3

in Fig. 3 indicates that the bolt will not fail by fatigue. Measuring the stress amplitude for the critical point *A* we find a value of 6500 lb per square inch, giving a total stress fluctuation of 13,000 lb per square inch. It follows then that $P_d/P_z=0\cdot37$. In practice, ratios of this order are only found in joints with rather flexible or tubular abutments, which are in the minority.

* Lecturer in Mechanical Engineering Design, University of Sydney.

† Tightening of the nut induces tensile and shear stresses in the bolt. The latter reduce the yield point by about 20 per cent when tightening occurs up to the yield point[2], and correspondingly less at lower initial stresses. However, bars with a circumferential or helical constriction, therefore also bolts, show a rise in both ultimate strength and yield point when basing their strength upon the minimum cross-sectional area. Also the yield ratio appears to be raised. The combined effect upon the load capacity of the joint is probably small and will here be ignored.

$P_d/P_z=0\cdot5$ would mean that $C_a/C_b=1$. It is, of course, advantageous to reduce the live load in bolts as much as possible, and this can be done by making the abutments rigid or, when this is not practicable, by using "elasticated" bolts. Compared with joints where $P_d/P_z\sim0$ and normally having the same total bolt load, those of larger ratios take more overloading before they open. The latter therefore are safer in this respect, but the gain is at the expense of the dynamic bolt load which may become too large.

We shall now apply a factor of safety to the endurance limit and to the external load. It is desirable that ample clamping load is maintained during the maximum load of each load cycle to ensure that the faces of the joint will not separate, which would cause a sharp increase in the live bolt load. The initial load should therefore be as high as possible, i.e. not too far from the yield point. This practice is so widespread, with good results, that it hardly needs to be questioned[4, 5]. It is a fallacy to apply a factor of safety to the initial load as has been done, in effect, in a recent textbook. With a sufficiently large factor of "safety" the joint would work loose in no time because of inadequate friction between nuts and bolts! We shall use a factor of safety=2; that is, the clamping load at the face of the joint equals the external load. This allows for eventual larger loads, and for some drop-off in the initial load through "working" of the joint. The total bolt load, moreover, will be limited to 90 per cent of the yield strength. This gives $S_z=0\cdot45S_y=15{,}750$ lb per square inch.

Allowing also for eccentric loading and bending of the bolts, non-uniform distribution of load, rough finish at the thread

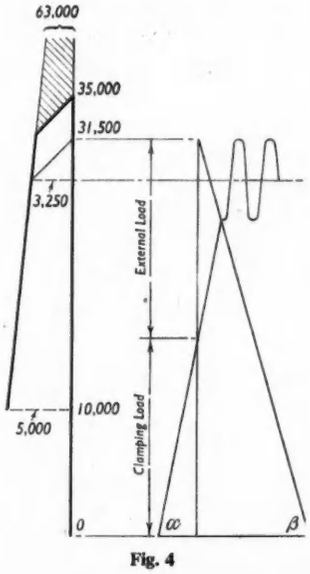


Fig. 4

root, &c., the same factor of safety will be applied for endurance. The above data have been used in the diagram of Fig. 4 and we find $P_d/P_z=0\cdot41$, a value slightly larger than that obtained before. It can also be seen that the initial bolt load is now higher than in Fig. 3, despite the reduction in total bolt load.

Judging from this example, a joint with such bolts and a P_d/P_z ratio smaller than, say, one-third cannot fail by fatigue when suitably tightened. This is the range of optimum and uniform load capacity and joints within this range are in the great majority. Generally speaking, therefore, the procedure of obtaining the permissible external load by dividing the yield strength of the bolts by a suitable factor of safety is a sound one, and not just a simplification for want of better.

The foregoing can be extended to high-tensile bolts. In many cases the stress concentration in the thread there appears to increase with the ultimate strength, the endurance limit being of the same order as in mild steel bolts. This results in a reduction of the critical P_d/P_z ratio. On the other hand, considerable increases in endurance limit are also known.[6, 7]

The following equation obviates the need for drawing diagrams.

$$K_c=\frac{R_t}{R_e}\cdot\frac{2P_e(P_u-P_t)}{P_t\left(P_u-P_m-\frac{P_e}{R_e}\right)}.$$

$K_c=P_d/P_z$ (critical).
$R_t=P_t/P_z$.
R_e=factor of safety on endurance limit.
P_e=load amplitude at endurance limit at a mean steady load P_m ($=P_e$ for a load cycle zero to maximum).
P_u=ultimate tensile strength.
P_t=total bolt load.

It can be seen that K_c is more or less independent of the magnitudes of the factors of safety when their ratio is constant. The latter is desirable for all-round safety of the joint.

The equation can also be used to find the permissible external load on joints $>K_c$ by solving R_t for given magnitudes of R_e and P_t. The equation is not applicable to joints $<K_c$ because calculated values of R_t drop below the permissible minimum and even below unity. Ample safety margins not only cause a levelling-out of initial loads but permit considerable errors in tightening.

REFERENCES

[1] M. Boomsma: "Loosening and Fatigue Strength of Bolted Joints," THE ENGINEER, August, 1955, pages 284–6; November, 1955, page 674.
[2] K. H. Lenzen: "Strength and Clamping Force of Bolts," *Product Engineering*, December, 1947, pages 130–3.
[3] H. F. Moore and P. E. Henwood: "The Strength of Screw Threads Under Repeated Tension," *Bulletin*, No. 264 (1934), University of Illinois Engineering Experiment Station.
[4] S. Oldberg and T. M. Ball: "Design Features of the Junkers 211B Aircraft Engine," *Journal of the Society of Automotive Engineers (Transactions)* 1942, November, pages 465–483.
[5] W. H. Graves: "Tightened Bolts Exceed Elastic Limit," *Machinist*, October, 1943, page 105.
[6] J. E. Field: "Fatigue Strength of Screw Threads," THE ENGINEER, July, 1954, pages 122–4.
[7] E. Lickteig: "Schraubenherstellung," 2nd edition, Verlag Stahleisen, Dusseldorf.

Datum Selection in the Drawing-Office

FUNCTIONAL REQUIREMENTS, INTERCHANGEABILITY AND PRODUCTION METHODS

By L. P. WAKEFIELD

IT is generally known that many production, inspection and servicing troubles normally experienced with new designs can be attributed to the engineering drawings. Difficulties of a complex nature, the extent of which is not generally realised, arise in the drawing-office when component interchangeability is a requirement and the possibility is that these same interchangeable components are to be manufactured at various independent factories. Ministry of Supply contracts, in particular, frequently require a proportion of sub-contracted work, a feature which calls for vitally important decisions (at the draughting stage), regarding the selection of data having in mind the most likely method of manufacture. This article is designed to typify a few of the difficulties outlined above, and to recommend action designed to eliminate common ambiguities. A brief discussion is considered essential at this stage, which pivots around a condition that might almost be described as paradoxical.

(1) Drawing-office personnel have first-hand knowledge of functional requirements, but no real opportunity, under conditions as indicated, to anticipate precise methods of production and inspection. It is not unreasonable that production methods should be decided by the production engineers.

(2) Production engineers and inspection personnel know their own equipment and rightly dictate methods of production and inspection. Their facilities for the recognition of functional requirements are usually remote, except by the medium of sensibly toleranced engineering drawings.

A point which is not overlooked here is that a production drawing-office, as the intermediary between the design office and the workshop, helps to eliminate some of these difficulties, but brings with it a disadvantage which cannot be ignored. The disadvantage is that a component drawing, dimensioned and toleranced on the basis that the exact method of manufacture is known (which surely is the definition for a production drawing) almost always fails to reveal the functional requirements—a feature which is of vital importance if flexibility in production methods is desired.

The above observations bring us to the application of fundamental principles for dimensioning and tolerancing. A valuable contribution in this respect is to be found in the *Dimensional Analysis of Engineering Designs*, an M.O.S. publication referred to below and quoted here as follows:—

(1) The requirements relating to interchangeability should be determined from following considerations, viz. simplicity and economy of production, inspection and servicing.

(2) Standard parts and sizes should be used wherever possible.

(3) Fits between mating parts should be arranged in general on the "hole basis." Shaft basis should only be used in special cases.

(4) The features of the details of an assembly should be carefully studied and design sizes should be first assigned to those dimensions which affect assembly or functioning or both. N.B.—the systematic analysis involved in following this principle will automatically establish the functioning datums.

(5) Where variations from the desired assembly and/or functioning requirements can be permitted only in one direction, appropriate unilateral tolerances should be assigned to the relevant design sizes of dimensions. Where variations can be permitted in both directions bi-lateral tolerances should be used.

(6) The functioning datums established by applying principle (4) should be examined for their suitability as economical production and inspection datums. If unsuitable for this purpose other datums should be chosen.

(7) Tolerances should be so assigned that no dimension is subject to redundant limits.

(8) The geometrical layout and the method of tolerancing of designs for complex work

should be scrutinised, and if necessary modified in the light of practical production and inspection requirements.

(9) Tolerances should be assigned to features for position, concentricity, symmetry, flatness, roundness, squareness and parallelism when the control of these elements is important for correct assembly or functioning, or both.

(10) Tolerances should be as wide as is consistent with satisfactory functioning, economical production and inspection. They should be scrutinised carefully to ensure that no special difficulties have been imposed without real functional necessity.

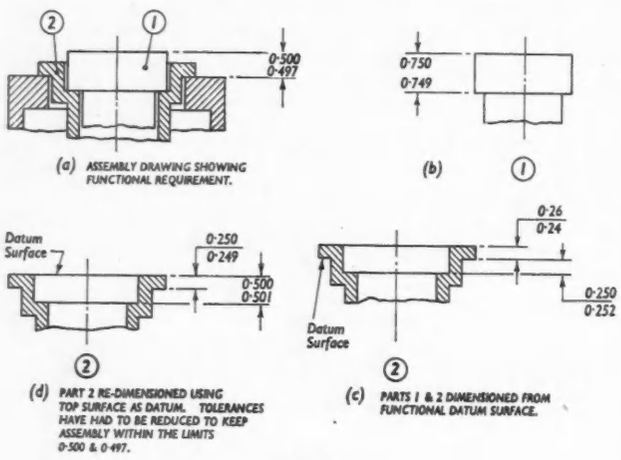


Fig. 1

Datum Selection

The outstanding observation here is that while principle (6) appears very desirable from the production and inspection viewpoint, it is sometimes impossible, and in the writer's opinion, misleading, as typical examples which follow are arranged to show, when linked with conditions already described. Clarification in conjunction with the latter point is found by quoting an important principle for dimensioning and tolerancing from British Standard 308 : 1953, "Engineering Drawing Practice," which reads : "The functional dimensions* should be expressed directly on the drawing. The application of this principle will result in the selection of datum features on the basis of the function of the product and the method of locating it in any assembly of which it may form a part. If any datum feature other than one based on the function of the product is used, finer tolerances will be necessary and products which would satisfy the functional requirements may be rejected for exceeding these finer tolerances."

It is clear that the latter principle conflicts with principle (6), and the draughtsman is faced with the problem, which method of datum selection is he to adopt ? Surely the only rule to apply is that the selection of datums should be dictated by functional requirements.

The illustrations here are arranged to show the importance of datum selection and, further, to draw attention to the penalties involved when data other than those selected for functional reasons are used. Fig. 1 is extracted from B.S. 308 : 1953, "Engineering Drawing Practice," and points out the penalties involved when a datum as shown at (*c*), selected for functional reasons indicated at (*a*), is changed to a datum which appears more convenient for measurements as at (*d*). A further possibility which cannot be ignored occurs when the draughtsman chooses to dimension a component drawing, not from functional requirements, but from a datum he considers better from a production point of view. The contractor may then decide that the datum shown on the drawing is unsuitable and select, in an extreme case, the very functional datum which the draughtsmen had rejected. In such a case there would be a double reduction in tolerance.

An instance such as this may be observed by referring again to Fig. 1. Suppose the manufacturer, on receipt of a drawing, as shown at (*d*), decides to control the depth of the counter-bore from the underside of the flange after all. In order to control the dimension 0·500/0·501, the maximum tolerance that could be allowed on the distance from the underside of the flange to the bottom of the counterbore, and also the flange thickness, would be 0·0005. The worst penalty becomes obvious in the comparison of the flange thickness tolerance, 0·0005 as against the tolerance 0·020 as dictated by functional requirements.

Non-Functional Dimensions

These dimensions should be placed in the manner most convenient to the producer or inspector.

Strictly speaking, this term is a misnomer —all dimensions are functional to varying requisite degrees of accuracy. It is generally understood, however, that dimensions upon which can be allowed comparatively wide tolerances are generally described in this way; penalties involved by the selection of datum features other than those based on the function of the product are not generally so severe with these dimensions.

The draughtsman is confronted daily with such decisions which, as shown in Fig. 2, could be described as irritating rather than vital. The example shown is a genuine instance which the writer came upon in a drawing-office where disagreement between draughtsman and checker was evident on the subject of datum selection for a very simple component. The drawing was a component drawing of a terminal board (shown partly dimensioned in order to make the point).

The functional requirements for this component are obvious, the centres of the fixing holes *A* require tolerance control to permit assembly. The disagreement was—in view of the fact that the positions of the terminal holes *B* are virtually non-functional, then their position could easily be given from the edge of the plate rather than from the centre line of holes *A*.

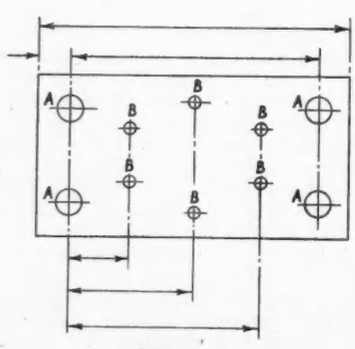


Fig. 2

This particular issue could be divided thus :—

(1) *In the Drawing-Office.*—Only if the position of holes *B* in relation to the position of holes *A* is required to be accurately maintained, would it be deemed sensible to

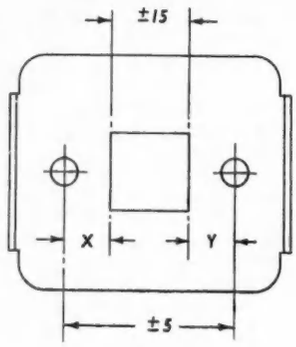


Fig. 3

dimension as in Fig. 2. The principle, that "non-functional" dimensions should be placed in a manner convenient to the producer or inspector, is slightly ambiguous, but common sense would suggest that the positions of *B* holes could be located from the plate edges.

(2) *The Producer.*—Obviously the producer can operate, whichever way dimensions are placed, so long as all are on the drawing. Countless drawings, however, exist where the producer is misled with regard to design requirements, as all examples here are intended to show.

We are led here to a form of appeal to users of drawings. If a component drawing, at first glance, appears to be dimensioned inconveniently or unconventionally—it is not always lack of foresight on the part of the draughtsman, but more often for a firm and sensible reason, advantageous in the end to the producer, in the light of real requirements. In facetious vein, the planner of a route—say, from London to Liverpool—would not normally project the route via Glasgow, the traveller may find it more convenient to go via Land's End, or even directly.

Another example of a simple component bristling with datum selection difficulties is shown in Fig. 3, a transformer clamp. The functional requirements in terms of tolerance are :

(1) Tolerance for size of rectangular hole ±15.

(2) Tolerance for centre distance of two small holes ±5.

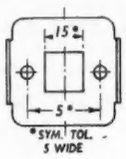
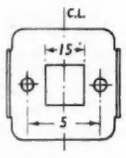
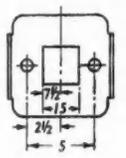
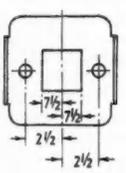
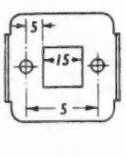
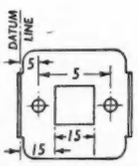
(3) Control for symmetry of the rectangular hole with the two small holes is desired.

No actual values are given to the dimensions shown. Figures given on diagrams are tolerances in units of thousandths of an inch. The various degrees of asymmetry are tabulated in the form of effects on distances marked *X* and *Y*.

Position Dimensions

Realisation that almost all engineering projects are, in theory, assemblies of various geometrical solids, assists appreciation of difficulties in datum selection. Dr. Abbott's book, *The Dimensioning of Engineering Drawings*, deals more fully with this aspect, includ-

*A functional dimension is one which directly affects the function of a product.

	Method of dimensioning	Penalties: Resultant symmetry tolerance	Penalties: Resultant tolerance on distance X	Penalties: Resultant tolerance on distance Y	Datum	Observations
A		5 (stated) or as required	15	15	Centre line	This direct method is recommended in B.S. 308 and provides the most consistent control, to suit functional requirements
B		0 assumed	10	10	Centre line (implied)	Symmetry is implied only in this case. Allowable asymmetry is strictly zero. Attempts to damp down ambiguity by the insertion of the sign C.L. are not recommended
C		20	10	30	Centre line	Tolerance values of one-half the normal value are quoted in the manner indicated. Penalties may well be prohibitive
D		10	10	10	Centre line	Tolerance values of one-half the normal value are used in a slightly different manner, resulting in a lower penalty value than at (c)
E		15	5	25	Hole centre	Has the advantage of using normal value tolerances, but with a noticeable penalty for distance Y
F		30	20	40	Edge	The datum selected here is an edge which is convenient for measurement; the penalties regarding possible asymmetry and variations for X and Y are heavy unless tolerances for dimensions shown are considerably reduced

Figures shown on diagrams are actual tolerances. Figures shown in table are resultant tolerances. All are expressed in thousandths of an inch.

Choice of Method.—The application of the principle discussed here that "Functional Dimensions should be Expressed Directly on the Drawing," will decide that method *A* above is preferred.

Note.—Method *B*, together with the use of the equals sign, is an accepted and long-established custom in many engineering concerns, but for reasons of its ambiguity should be discontinued.

ing the division of dimensions into three distinct categories specified as size, position and form. It should be clear from the foregoing examples that datum selection difficulties in the drawing-office are, indeed, real in the case of position dimensions. Complexities in this category are also brought to light in *Dimensional Analysis of Engineering Designs* (a Ministry of Supply–H.M. Stationery Office publication by an Inter-Services Committee for Dimensioning and Tolerancing Drawings). Both the above publications, together with British Standard 308, "Engineering Drawing Practice," show that the least ambiguous method for the dimensioning of drawings is achieved by quoting functional dimensions directly. The application of this principle in particular to position dimensions (dimensions of hole centres, for example) appears at first glance unconventional, even inconvenient, to the people whose job is to produce the article from the drawing. Using a simple yardstick, however, in formulating conclusions of this sort, is popular, but not in keeping with the depth of the subject, a subject involving Euclidean definitions and also the six-point location principle, to which reference is made in the above M.O.S. publication.

The crux of the question regarding position dimensions emanates here, strict adherence to the rule of quoting functional dimensions directly on the drawing demands the use of positional tolerances—giving the permissible amount of variation from theoretical (and obviously functional) positions—usually centres. Two exceptions, should they be considered worthwhile, could be made thus:

(1) Where the position of only two features (hole centres, for instance) are to be related.

(2) Where the function of the parts concerned, permits the use of wide tolerances (see Fig. 2).

Finally, additional advantage to production and inspection departments is made possible, when it is realised that positional tolerances are, of necessity, based on maximum metal conditions (i.e. an assembly function where hole sizes are the smallest allowable and screw, rivet or pin sizes are the largest allowable). Depending upon the amount of tolerance allowable on these features, increased tolerance zone for position becomes available. In other words, the draughtsman is revealing to producers and inspectors additional licence based on functional requirements.

There is one other difficulty worth mention. New terms and expressions, used on drawings, are not often welcomed, even when advantages accrue, to users of drawings, which is the obvious reason why industry is not using all recommendations made in B.S. 308 on "Engineering Drawing Practice." The writer, in a drawing-office training capacity, has experienced no difficulty with instruction along the lines indicated. Much more problematical, however, is the decision—to which set of manufacturing circumstances do we apply the slightly unconventional, but watertight, recommendations recorded here, in the British Standard 308, and other comparatively new publications, in which a strictly legal approach to achieve dimensional control is devised in order to keep pace with manufacturing circumstances outlined above.

One might well ask the question, why should it become necessary after years of successful engineering and manufacture to introduce new and refined methods for dimensioning? Component interchangeability is being successfully achieved by the use of cross reference notes on each separate drawing of mating components, giving the planning department (or shop foreman) opportunity to decide where jigs are required. This brings us back to the paradoxical situation referred to at the beginning of this article, and to say—if the draughtsman knows beforehand, in detail, the exact manufacturing circumstances, then a great deal of licence in draughtsmanship can be permitted. The alternative, where manufacturing circumstances are unknown, justifies the existence of this article.

COMPONENT HANDLING AT MACHINES.—The material handling division of Fisher and Ludlow, Ltd., Bordesley, Birmingham, 12, has introduced what is known as the "Flowfeed" automatic delivery system for the handling of components delivered by box stillages to machining stations. For this equipment a specially designed hopper stand is installed beside the machine with the hopper holding the component blanks conveniently near. Corrugated steel box pallets are used for transporting the components and are brought to the machine by fork lift truck. This fork lift is used to elevate the incoming box pallet of blanks and set it on inclined ways on the upper part of the hopper stand. A sliding door at the bottom on one side of the pallet is then opened for the blanks to gravitate into the hopper. At the end of the machining operation components are dropped into a chute situated at the front of the hopper, and they slide down this chute into a second box pallet ready for transport to the next machining station. A sufficient supply of components is held in the hopper to enable production to continue whilst box pallets are being changed on the stand.

British Columbia-Vancouver Island 138kV Submarine Power Cable

On September 25, 1956, five submarine power cables, linking the lower mainland of British Columbia with the southern portion of Vancouver Island, were put into service. This brought to a close four years of planning, engineering and construction to meet the rising electrical needs of the territory served by the British Columbia Electric Company, Ltd. (B.C.E. Company), on Vancouver Island. The background and novel features of the project were described in a paper presented to the Institution of Electrical Engineers, London, on April 25, by T. Ingledow, R. M. Fairfield, E. L. Davey, K. S. Brazier and J. N. Gibson. The following abstracts from the paper deal mainly with manufacture and installation of the cable.

DURING the past seven years, the Vancouver Island system of the B.C.E. Company experienced a persistent load growth in excess of 10 per cent compound per annum, and a continuation of this trend is expected for some years to come. During the winter of 1955–56, the one-hour peak load reached 75MW and practically equalled the system peaking capability. This situation had been anticipated on the basis of load studies made several years ago, when it became evident that an additional source of power would have to be provided during 1956. There was also a need for additional peaking capacity from the standpoint of system reserve, since all four units at the Jordan River hydro-electric plant are served by a single wood flume, making them vulnerable to simultaneous outages ; in addition, the Brentwood steam plant contains some 4MW of obsolescent and inefficient units. With the possible termination of the purchased power contracts, about 120MW of additional power will be required over the next six or seven years to provide the necessary peaking capability and system reserve.

Alternative Methods of Supply to Vancouver Island

In the absence of additional sources of hydro-electric or purchased power, consideration was given to a conventional thermal plant, an atomic power plant, and a submarine cable interconnection for transmitting hydro-electric power from the B.C.E. Company mainland system.

It was estimated that the cost of power from a modern 120MW steam plant with two units, operating at 60 per cent capacity factor and burning Bunker C oil or coal, would be between 0·7 cent and 0·8 cent per kWh (0·62d.–0·71d.), including fixed charges, operation, labour, maintenance and delivered fuel cost.

An atomic power plant of 120MW capacity was not available commercially for service in 1956. Furthermore, estimates indicated that atomic power would be considerably more expensive than power from a conventional steam plant, at least for some time to come.

The unit cost of transmission over a 120MW submarine cable interconnection was estimated at slightly above 0·1 cent per kWh (0·089d.) when operating at 60 per cent capacity factor. Using hydro-electric power from the mainland system, the total cost of power delivered at the Stratford switching station on Vancouver Island via the submarine cable interconnection would be lower than the cost of power from a local steam plant. The unit cost of transmission over the interconnection would embrace operation, maintenance and fixed charges on five submarine cables (two of which would be spares), chases and landing facilities for seven cables, and provisions for expansion at the substations. Ultimately, there would be seven submarine cables—three for each circuit and one spare—thereby doubling the capacity of the interconnection to 240MW and further lowering the unit cost of transmission.

Apart from the economic advantages, other benefits would accrue from an interconnection between the mainland and Vancouver Island systems. The hydro-electric plants on the southern portion of Vancouver Island are subject to the run-off characteristics of one watershed ; in a dry year there is the danger of an energy shortage, and in a wet year water may have to be spilled. An interconnection with the mainland system would improve the co-ordinated use of several watersheds having diverse run-off characteristics, resulting in more efficient use of the company's water resources. Also one block of reserve capacity for emergency conditions would suffice for both systems.

It was evident, therefore, that an interconnection by high-voltage submarine power cable would be very attractive. A decision was taken to proceed with it, based on a 138kV, 60 c/s system, to link up with the existing system.

The total length of the interconnection is 43 miles. Starting at Arnott substation of the B.C.E. Company mainland system, it runs by way of an overhead transmission line to a point near the International Boundary at Tsawwassen Beach. Here a 14·7-mile section of submarine cable crosses the Strait of Georgia to Galiano Island, running down to a depth of 600ft. It should be noted that, with the permission of the American authorities, the cables take the shortest route across the Strait through United States territorial waters for a distance of about 7 miles.

From Galiano Island a connecting overhead transmission line crosses over to Parker Island, where a further 2·9-mile section of submarine cable runs under Trincomali Channel to Saltspring Island. Another section of overhead transmission line then traverses Saltspring Island and spans Sansum Narrows, which is over a mile wide ; and the line proceeds to Stratford terminal station, where it links up with the B.C.E. Company–Vancouver Island system.

Circuits, Protection, Control and Communication Systems

The 138kV overhead-line sections have four conductors and connect to four submarine cables. Three cables are used at any one time for the three phases of the interconnection, while the fourth circuit can be switched at the terminal stations as a spare for any phase. A fifth cable serves as stand-by at present, and provision has been made for an additional two cables at a future date. Ultimately there will thus be seven cables, providing two 120MW, three-phase interconnections with one common spare circuit.

Both terminal stations are unattended and controlled by supervisory carrier-current equipment from the load-dispatch centres in Vancouver and Victoria, respectively. Two-zone impedance relays are used for phase protection, and high-speed directional earth-impedance relays for earth protection. A single-zone impedance back-up relaying scheme is provided to guard against failure of the primary relays and circuit breakers. In the event of a phase-to-earth fault the circuit breakers at the terminal stations are tripped and the spare circuit is automatically substituted for the faulted phase, using motor-operated switches. The mainland circuit breaker is then reclosed, and the Vancouver Island system is resynchronised, either manually or automatically, from the load-dispatch centre in Victoria.

Communication and gas-pressure alarm facilities are provided through the co-operation of the British Columbia Telephone Company. Low-gas-pressure alarms are signalled at the telephone exchanges closest to the cable terminals. An audible alarm is given, together with two signal lights for gas failure and one light for circuit failure. Alarm conditions are reported by the exchanges to the B.C.E. load-dispatch centres.

Development and Design of Cable

The basic problems associated with the cable design were mechanical rather than electrical. It was considered that the cable must be manufactured in continuous lengths to avoid the hazards and complications of jointing separate lengths at sea by means of rigid submarine joints. This concept of continuously manufactured lengths had received much support from the evidence and experience obtained from previous work carried out in conjunction with the Central Electricity Authority on the cross-Channel cable project.[1,2] The decision to adopt the single-core, gas-filled type of cable, using pre-impregnated paper insulation[3] followed logically, this being the only practicable type which lent itself to continuous manufacture and which could be developed for the duty required.

The cable was required to operate at 138kV, three-phase, 60 c/s, with a rating of 120MVA. The maximum external sea-water pressure would be 265 lb per square inch, and in order to prevent extensive ingress of water into the cable in the event of damage, it was designed to operate at 300 lb per square inch nitrogen gas pressure.

The constructional details of the cable design which finally emerged from the development stage and the two sea trials are briefly summarised in Table I, and the more important technical details are given in Table II. The cable comprises the following :

A circular screened copper conductor of area 0·35 square inch with central gas duct ; pre-impregnated paper insulation, copper-tape screened ; lead-alloy sheath reinforced with bronze tapes ; anti-corrosion sheath, galvanised steel wire armour and serving.

Conductor and Insulation.—The cable was designed on the basis that all coiling would be in a clockwise direction. The outer layer of conductor wires was stranded right-hand, so as to contract in diameter under coiling, thus avoiding damage to the dielectric papers. The central duct was designed to provide the gas-flow channel ; the clearance under the lead sheath—which is standard practice in the case of land cables—is inadmissible, since at depths in excess of 40 fathoms the sheath would tend to deform under the external water pressure. The insulating papers were applied with graded thicknesses and tensions in four reversed-lay sections.

Table I—*Cable Construction*

Component	Radial thickness, inches		Cumulative diameter, inches
Spiral steel duct (internal diameter 0·47in)	0·030	...	0·530
Copper conductor 42/·105in 0·35in²	0·210	...	0·950
Metallised paper conductor screen	0·0105	...	0·971
Pre-impregnated paper dielectric	0·575	...	2·121
Copper-tape dielectric screen	0·003	...	2·129
Alloy E (B.S. 801 : 1953) sheath	0·150	...	2·429
Reinforcement bedding	0·012	...	2·453
Tinned 1 per cent tin-bronze reinforcing tapes (3 × 0·009in)	0·027	...	2·507
Compounded cotton tapes	0·027	...	2·561
Vulcanised - rubber anti - corrosion sheath	0·120	...	2·801
Armour bedding	0·118	...	3·037
Single-wire armour, galvanised steel, 25–32 tons per square inch tensile	0·232	...	3·501
Bituminised cotton tape	0·050	...	3·601
Jute serving	0·180	...	3·961

Gas Retaining Sheath and Reinforcement.—Alloy E was adopted for the sheathing, after careful study of the properties of alternative alloys, and having particular regard to the necessity for high fatigue resistance. The diametral strain, imposed on the sheath in the course of transferring its hoop stress to the reinforcement in service, was determined as 1·2 per cent maximum, while the ultimate diametral strain of the sheath itself is 4·0 per cent minimum at rates of strain down to 10^{-4} per cent per hour. The sheath was extruded on to the insulation with a shrinkage of 30–40 mils diametral, to obviate distortion under external water pressure while the cable was being laid without internal gas pressure.

The reinforcing tapes were applied with a right-hand lay (i.e. opposite-hand to the armour) in three layers, so that, under the tensile loads experienced during laying, their circumferential torque was opposed to and practically equal to that of the armour. Under coiling conditions, the tensile strain imposed on the tapes was within their elastic limit. This substantially

reduced any tendency of the cable to throw loops on the sea bottom under certain conditions of laying and recovery.[4]

Anti-Corrosion Sheath.—This consists of a homogeneous and fully vulcanised sheathing of natural rubber compound, and performs the highly important function of protecting the reinforced gas-retaining sheath against corrosion. It provides adequate insulation against the transient voltages (approximately 10kV) which may be induced between the armour and the gas-retaining sheath in service.

Steel-Wire Armour.—This consists of galvanised steel wires applied with a left-hand lay to avoid locking during the clockwise coiling. The optimum lay was determined, by experiment, as twelve times the pitch-circle diameter, to provide the desired coiling and handling properties consistent with minimum torsion under the tensile loads of laying. Much work was done on various aluminium alloys with the object of reducing the electrical losses in the armour. Although their normal electrical and mechanical properties were satisfactory, it was found that, under water, the abrasion resistance was much inferior to that of steel, and for this reason the use of aluminium wire armour was rejected and galvanised steel was adopted.

TABLE II—*Technical Data of Cable*

Conductor area	0·35in²
D.C. resistance of conductor at 20 deg. Cent.	0·0705 ohm per 1000 yards
D.C. resistance of sheath at 20 deg. Cent.	0·284 ohm per 1000 yards
D.C. resistance of reinforcement at 20 deg. Cent.	0·471 ohm per 1000 yards
D.C. resistance of armour wires at 20 deg. Cent.	0·119 ohm per 1000 yards
Weight in air	52·3 lb per yard
Weight in sea	37·5 lb per yard
Minimum permissible bending diameter	6ft
Minimum permissible coiling eye diameter	10ft
Maximum permissible twist	36 deg. per yard
Maximum permissible tensile load	6 tons
Tensile modulus	0·017 per cent per ton
Torsional modulus	0·3 deg. per yard per ton tension
Apparent 60 c/s resistance of cable at operating temperature :	
500 yard spacing	0·153 ohm per 1000 yards
250 yard spacing	0·153 ohm per 1000 yards
Apparent 60 c/s reactance of cable at operating temperature :	
500 yard spacing	0·0972 ohm per 1000 yards
250 yard spacing	0·0994 ohm per 1000 yards
Capacitance	0·193μF per 1000 yards
Working voltage to earth	80kV
Electrical stress at conductor	85kV per centimetre
Electrical stress at screen	39·5kV per centimetre
Dielectric loss angle (at working voltage 60 c/s) :	
At 20 deg. Cent.	0·0039
At 50 deg. Cent.	0·0033
At 85 deg. Cent.	0·0030
Permittivity	2·9
Charging current, 60 c/s per cable	5·8A per 1000 yards
Current rating	500A
Losses per three-phase circuit :	
Conductor	60·5kW per 1000 yards
Dielectric	3·5kW per 1000 yards
Sheath reinforcement and armour	55·0kW per 1000 yards
Total	119kW per 1000 yards
Maximum conductor operating temperatures :	
In sea	50 deg. Cent.
On land	70 deg. Cent.
Maximum sheath temperatures :	
In sea	30 deg. Cent.
On land	47 deg. Cent.
Soil resistivity :	
On sea bed	30 thermal ohm-cm
On land	120 thermal ohm-cm
Average ambient temperature :	
In sea	15 deg. Cent.
On land	15 deg. Cent.
Cable spacing :	
Strait of Georgia	500 yards
Trincomali Channel	250 yards

Typical Performance Characteristics.—The following are typical of the extensive performance tests carried out on the cable :

Electrical stability : Fifty heating cycles to 90 deg. Cent., conductor temperature at 1·5 times the working voltage with 200 lb per square inch gas pressure. The cable was then maintained at 90 deg. Cent. and 1·5 times the working voltage until thermal stability was proved.

Surge withstand : 675kV (peak) for ten positive and ten negative impulses, with the conductor at 85 deg. Cent. and the cable under 200 lb per square inch gas pressure.

Bending test : The cable, at atmospheric pressure, was bent three times each way in reverse directions around a drum of diameter twenty times that of the cable sheath (i.e. 49in), followed by a withstand test of 300kV d.c. for fifteen minutes.

Coiling test : The cable, at atmospheric pressure, was coiled down three times to a coiling diameter of 10ft, followed by a withstand test of 300kV d.c. for fifteen minutes.

Bending test under tension : The cable, at atmospheric pressure, was subjected to six bends around a 7ft 6in diameter sheave under a 6-ton tensile load, followed by a withstand test of 300kV d.c.

External water-pressure withstand : The cable, at atmospheric pressure, was subjected to 400 lb per square inch external water pressure for fourteen days, with no distortion.

Internal gas-pressure withstand : The cable was subjected to internal gas pressure of 600 lb per square inch for fourteen days.

The reconstituted cable joint was subjected to the same performance tests as for the cable, except that the surge-withstand voltage was 600kV. The submarine repair joint was tested, as for the cable, for electrical stability, surge-withstand, external water-pressure withstand and internal gas-pressure withstand ; in addition, tests were carried out to prove the performance under tensile loading and handling conditions. The sealing ends were tested as for the cable for electrical stability, surge-withstand, and internal gas-pressure withstand.

Design of Terminal Equipment and Joints.—The use of the hollow cable conductor as a gas duct made it necessary to modify the conventional sealing-end design which is used for land cables, as the feed pipe was at line potential. A double porcelain arrangement was employed.

For maintaining gas pressure in the cables, gas-feed equipment was installed at each terminal site. The gas cylinders were connected to the sealing ends through the usual arrangement of reducing valves and pressure gauges, the latter being provided with electrical contacts to give warning of falling pressure, either from cylinders or cables, in the event of a leakage. A novel system was incorporated, whereby the maximum rate of gas flow would be automatically controlled to a value just sufficient to maintain the pressure necessary to prevent the ingress of water in the event of severe damage to a cable, such as, for example, a complete severance. Provision was made for gas-leak location panels at each terminal site.

As explained earlier, it was intended that the cables should be manufactured and laid without joints. It was appreciated that this ideal might prove to be unattainable, and so joints of two types were developed. The first was a reconstituted joint of the same dimensions and flexibility as the cable itself ; this was intended for use in the factory if an accident should occur at any stage up to and including lead sheathing. The second type of joint was a rigid submarine repair joint for use if a cable should need repair after laying. As it transpired, both were needed in the project.

CABLE MANUFACTURE

In designing the plant and its layout for the manufacture of the continuous lengths of cable required, particular consideration had to be given to the method of storage of the long lengths of cable in between the various stages of manufacture, and to the best means of enabling the insulating and lead-sheathing operations to be carried out in tandem. It was clearly not satisfactory to leave the insulated and screened cable exposed to the atmosphere for many weeks.

The plant was designed for the following sequence of operations, which are illustrated diagrammatically in Fig. 1 :

(*a*) Stranding of conductor on to No. 1 turntable.

(*b*) Strand from No. 1 turntable insulated and lead-sheathed in tandemn, using an accumulator system, the lead-sheathed cable being taken up and stored on No. 2 turntable.

(*c*) Lead-sheathed cable from No. 2 turntable reinforced, vulcanised-rubber sheathed, armoured and served ; and the finished cable conveyed by gantry and coiled down in the coiling shed.

(*d*) Cable transported from the coiling shed by overhead gantry and loaded into the tanks of the cable ship for shipment to site and subsequent laying.

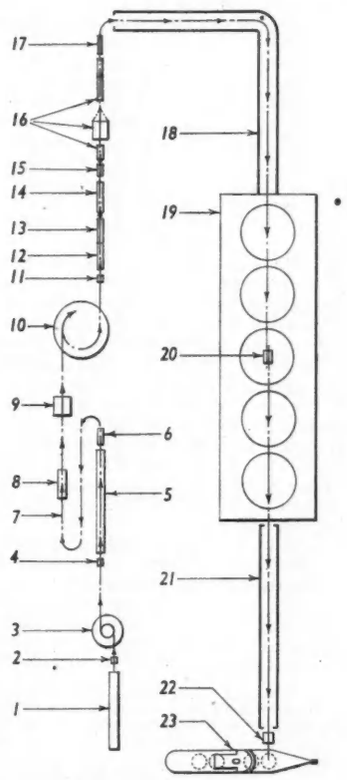
Much of the plant and equipment employed follows existing design practice, and only those items which have been specially developed for the project are briefly described.

Stranding Machine.—This is a standard floating-bobbin, two-carriage machine. Novel arrangements had to be made to take the conductor away from the capstan and feed it on to No. 1 turntable. A capstan system of haul-off will not operate with zero output tension owing to slipping, and since the strand has to be fed from the strander on to the turntable at zero or very low tension, a small caterpillar haul-off is employed on the output side of the capstan to maintain a small output tension. This caterpillar haul-off is fitted with "Neoprene" pads driven through a fluid drive and is mounted over the capstan so that the conductor may be fed on to the No. 1 turntable from above.

Storage of Conductor (No. 1 Turntable).—The normal method of storing a long length of cable is to coil it on the ground, but this twists the cable through 360 deg. for every turn of the coil. It was decided that twisting of the cable should be reduced to a minimum at every stage of manufacture except in its finished state, and that large power-driven horizontal turntables should be installed for coil-storing the cable between operations.

To receive and coil-store the conductor, such a turntable, 24ft in diameter, was installed between the stranding and insulating machines designed to accommodate up to 25 miles of conductor of 1·0in diameter. It is driven through an electronically-controlled magnetic coupling, giving constant speed at any load. Owing to the difference in speeds between coiling down from the stranding machine and paying-off into the insulating machine, the drive was fitted with two gears and a two-speed motor.

Insulating Machine.—This is a rotating-cage



1. Stranding machine.
2. Caterpillar haul-off.
3. No. 1 turntable.
4. Caterpillar brake.
5. Insulating machine in enclosure.
6. Capstan haul-off.
7. Accumulator system.
8. Accumulator output capstan.
9. Lead press.
10. No. 2 turntable.
11. Caterpillar brake.
12. Reinforcing tape heads.
13. Rubber taping heads.
14. Vulcaniser.
15. Spark testers.
16. Jute bedding, wire armouring and serving machines.
17. Capstan haul-off.
18. Transport gantry.
19. Coiling shed.
20. Coiling winch.
21. Loading gantry.
22. Loading caterpillars.
23. Cable ship.

Fig. 1—Diagram of plant for continuous manufacture of submarine power cables

type lapping machine of special design, having four cages, each capable of applying fifty paper tapes. The heads are of a constant tension type, regardless of paper-pad diameter, and they give true tangential and precision application; a separate head applies the copper screening tape. As the paper applied to the cable is pre-dried and impregnated, special measures are taken to eliminate contamination and to control the moisture pick-up during any enforced long stoppages of the machine. The insulating machine is therefore fully enclosed with a drying plant to maintain the atmosphere within the enclosure at uniform humidity, which can be reduced to 3–4 per cent in the event of a prolonged stoppage. Fitted into the sides of the enclosure are a number of cabinets for storing the pads of paper after cutting. These have doors on both sides so that the pads can be fed into them from outside, for use by the operators working inside the insulating machine enclosure. The humidity of these cabinets is maintained at 3–4 per cent.

Accumulator Between Insulating Machine and Lead Press.—As has been explained, it is necessary to run the insulating machine and lead press in tandem. It is, of course, impracticable to run the two machines synchronised together as this would necessitate stopping the insulating machine for several minutes whenever the lead press stopped for recharging and, even more important, stopping the lead press whenever the insulating machine stopped for renewing papers. An accumulator system was designed and installed between the two machines to store 130 yards of cable and so enable the lead press to run for up to three hours at normal production speed with the insulating machine stopped; in an emergency the lead press could run for up to twenty hours should a breakdown of the insulating machine require it.

The accumulator consists of a large eight-fall pulley system mounted horizontally. One set of four pulleys is fixed and the other set of four is moving, being mounted on a trolley which runs on rails erected over the insulating machine; all the pulleys are of 15ft diameter. A dead-weight system provides the necessary tensioning between the fixed and moving pulleys, the spans of cable between them being supported by a system of rollers.

The cable is metered out of the accumulator system to the lead press by means of a double capstan passing the cable in a catenary on to a roller conveyer which leads the cable into the lead press. This capstan is driven by an electric motor through a variable-speed gear, control of which is by means of a roller resting on the cable in the catenary. When the lead press starts or speeds up, the cable lifts slightly, raising the roller, which, in turn, starts or speeds up the capstans; the arrangement thus automatically meters the cable from the accumulator into the lead press at low and uniform tension and at precisely the speeds required.

Lead Press.—In a programme of continuous manufacture such as this, it was essential to ensure that the plant would be capable of running continuously for periods of 500 hours or more. From this aspect, the most vulnerable unit was the lead press, where a stoppage of ten minutes would so damage the cable as to necessitate cutting it out.

The press employed was a standard 1000-ton upstroking type with jack-ram return, fitted with the Glover vacuum method of filling;[5] prolonged trials had confirmed that this was suitable for the continuous extrusion of Alloy E sheathing for periods of up to thirty days.

As a safeguard, the pumps and control console were duplicated, any necessary changeover being possible within a few minutes. The hydraulic pressure was limited to 200 lb per square inch during a pre-set period following recharging, thus rendering it impossible, by starting extrusion prematurely, to cause a lead blow up the ram.

A special γ-ray photographic unit was developed for measuring regularly the sheath thickness at four positions at right angles to each other, without interruption of production. The γ-ray source is 2 curies of cobalt 60 in a heavily screened container with a remotely controlled shutter.

Storage of Lead-Sheathed Cable (No. 2 Turntable).—A second turntable, 47ft in diameter, was installed between the lead press and reinforcing machine; this will accommodate up to 25 miles of cable measuring approximately 2·5in in diameter.

Reinforcing and Armouring.—The application of the reinforcing tapes, vulcanised rubber anti-corrosive sheath, bedding, steel wire armour and serving was carried out in tandem in machines driven from a common backshaft.

Spark Testing.—To ensure complete integrity of the rubber sheath over the reinforcing tapes, it was tested at 20kV by two spark testing units in tandem. These were interlocked with the main motor drive so that voltage was applied whenever the cable was moving, and the motor could not run if the voltage to the spark testers failed. In addition, a failure in the rubber sheath automatically stopped the armouring machine motor to allow inspection and repair to be made.

Storage of Finished Cable.—The cable is transported from the capstan of the armouring machine by overhead gantry and coiled in the coiling shed. In order to coil the cable satisfactorily it is necessary to lower it from a height, and for this purpose a structure was erected comprising towers 45ft high and 64ft apart, with a bridging gantry between them. In the middle of the gantry a winch was installed, consisting of a 10ft 6in diameter V-grooved wheel driven by an electric motor through fluid coupling. The starting and stopping of the winch was controlled by a loop of cable between the armouring machine capstan and the start of the overhead gantry.

Loading into the Cable Ship.—To load the cable into the cable ship for shipment and laying, an overhead gantry was built from the coiling site to the dockside—a distance of 350 yards. Two caterpillar winches, each capable of exerting a pull of 4 tons, were installed on the dockside tower, to pull the cable from the coiling site for coiling into the tanks of the cable ship.

Quality Control.—It was not practicable to test the cable under high-voltage a.c. conditions and full gas pressure, either during or on completion of manufacture, owing to the lengths involved, and to the fact that full gas pressure could not be applied without impairing the flexibility and handling properties of the cable before laying.

It was, therefore, essential to take quite exceptional measures to control the uniformity and quality of the cable throughout all stages of manufacture: for example, at the start and finish of each length manufactured, lengths were cut off for complete testing and dissection to confirm compliance with the specifications. High-voltage d.c. tests and pneumatic tests at reduced gas pressure were carried out on the full lengths of cable in the lead-sheathed stage (No. 2 turntable) and the finished stage (coiling shed).

Cable Installation

The cable was shipped to site and laid by the cable ship "Ocean Layer."[6]

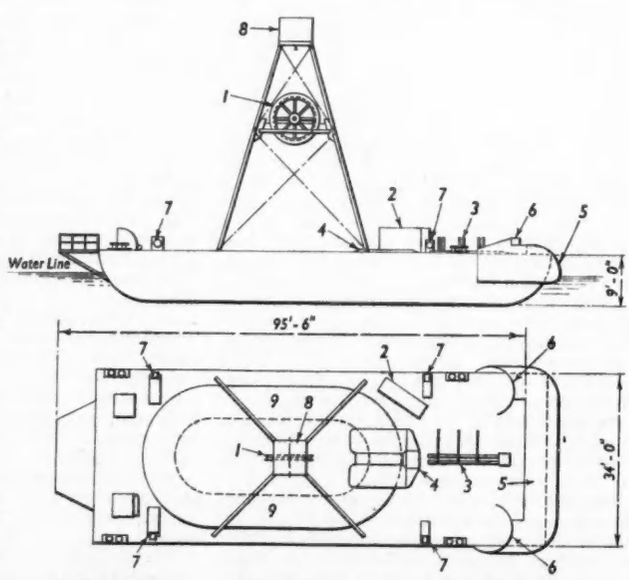
The greater part of each cable was laid from the cable ship using established methods. In order to maintain correct spacing of the cables under the somewhat difficult tidal conditions, it was decided to bring the ship to a pair of mooring buoys roughly parallel to the shore near the end of each crossing.

The use of continuous cable lengths precluded laying shore ends separately, and special attention was focused on the problems of getting the ends ashore. Scows, or barges with shallow draught and large, flat decks, are used extensively in the Vancouver area, and it was decided to adapt these local craft for laying cables from ship to shore. For a starting end the required cable length would be coiled on to a scow adjacent to the ship at moorings and would be laid from the scow coil to the shore, where the balance would be pulled by the free end up the cable chase to the sealing ends, using a power winch. After laying cable by ship to the finishing-end moorings, a bight would be pulled on to the scow deck and the remaining length transferred from the ship and coiled down before laying to the shore and pulling to the sealing ends.

Cable lengths to be transferred to the scow at the starting and finishing-end moorings would be around 2000ft in all cases, except at the mainland, where they would be a little over 9000ft, their weights being approximately 16 long tons and 72 long tons, respectively. It would be necessary to devise gear for carrying out this work and to have it fitted to suitable scows, bearing in mind that the twist introduced in coiling must be removed as the cable was laid. This would happen normally at a starting end when the scow leaves the ship, paying out cable towards the shore, and also at a finishing end when the cable is pulled up the chase from the scow. However, pulling up the chase at a starting end and laying from ship to shore at a finishing end would introduce a double twist in the cable if paid out in the normal way. It was proposed to obviate this difficulty by paying out cable under the turns of the coil.

Cable Scow.—The problems of handling shore ends were studied using models, and later a full-size dummy scow and ship on land. It was confirmed that "double twist" could be avoided by paying out the cable from underneath the coil through a "tunnel," and using a device called a "spinner." This is a semicircular frame with rollers suspended above the cable coil and free to rotate about a vertical axis. Cable is led over this, down round a set of rollers at deck level and under the coil through the "tunnel." This amounts to paying out the coil from underneath, which is equivalent to turning it over. A clockwise coil becomes counterclockwise when viewed from underneath, and so the twist imposed by clockwise coiling viewed from above is removed by a counterclockwise movement as cable is virtually paid out from the bottom of the coil.[7]

As a result of this work, a cable scow was designed, as shown diagrammatically in Fig. 2. A reversible power-driven cable sheave is mounted centrally 25ft above the coiling area on deck on an A-frame structure. Intended primarily for coiling down cable transferred from the ship and for laying the long shore approach to the mainland, it is driven by hydraulic variable speed gear, also arranged for braking. A compression-type cable brake is fitted at the stern, so arranged that the cable can be lifted in and out and the brake can be removed bodily in sections to clear



1. Cable sheave.
2. Prime unit.
3. Cable brake.
4. Tunnel.
5. Stern apron.
6. Curved side plates.
7. Winches.
8. Navigation platform.
9. Cable coiling area.

Fig. 2—Cable scow

the deck for handling cable bights. A tunnel consisting of wooden ramps with a removable top plate is provided so that cable can be paid out under the remaining turns as previously described. At the stern, a rounded " apron " is built up and extended round the sides, merging into vertical curved plates, so that cable can be pulled off in almost any direction without too sharp a bend. The scow is equipped with winches for warping and cable handling. V.h.f. radio and loud-hailers, a compact galley and store below deck, and a navigation platform at the top of the structure complete the equipment.

In addition to the fixed equipment on the scow, a simple lifting frame of the required radius was used for getting the cable on and off the sheave wheel. A " bight puller," consisting of a series of rollers on hinged frame sections with bending limited to a safe value, was also used for pulling the cable bight on to the deck of the scow at a finishing end.

Laying From Scow.—For the laying and landing of the starting ends a scow was moored alongside the ship, and the required length of cable was transferred using the cable sheave. Except at the mainland, the scow was then warped to the shore, paying out cable from the coil, over the cable sheave, through the brake and over the apron. At the mainland, however, the scow was towed for the first mile by shallow-draught tugs to dolphins about half a mile out, where ropes were picked up for warping to the shore. The tension in the cable was maintained by adjusting the speed of the sheave to maintain an angle of cable entry into the water of approximately 60 deg. to the horizontal. When the scow arrived at its prepared position close inshore, it was moored, the cable was removed from the power sheave, and the spinner was rigged for the free end to be pulled away through the tunnel and over the apron to the terminal position. During this operation the tension on the cable on the sea side was taken by a stopper and rope attached to the scow. When the final bight of cable approached the apron, a further stopper was fitted on the land side so that all tension was removed from the bight. This was lowered over the apron by pulling the cable slowly ashore, at the same time releasing the tension on the two stoppers until the bight was pulled out.

At the finishing end the cable ship was moored to the buoys and the scow was moored in line ahead. A stopper was fixed to the cable and the weight of the suspended cable was transferred to the scow. Between the cable stopper and the bow sheave the bight puller was fitted over the cable. A bight was then pulled out over practically the whole length of the deck of the scow and the seaward cable was placed in the tunnel and the cable brake. The cable from the ship was lifted on to the scow sheave and the shore length was paid out from the ship and coiled down on the deck of the scow. By paying out cable to the shore from underneath the coil, using the spinner and tunnel previously described, it was laid without residual twist. When the scow had been warped into position at the landing site the cable was removed from the spinner and the free end was passed over the power sheave and pulled ashore. The final bight of cable was handled in the same manner as a starting end.

As soon as possible after laying, the shore ends were inspected by a diver, and subsequently articulated split cable protectors of malleable cast iron were fitted for a suitable distance from the foot of each chase. The cables were then buried on the foreshore by digging or water-jetting.

Laying From Ship.—To avoid the risk of throwing loops or kinks in the cable, it was decided that it should be laid with a small residual tension on the sea bottom. A theory developed and checked during sea trials (which will be published later) was used to calculate the position of the " touch down " point of the cable in relation to the position of the echo-sounder in the ship, the shape of the suspended cable and also the tension required at the dynamometer on the deck to maintain the desired residual tension in the cable on the sea bottom.

The route profiles were plotted from hydrographic survey charts, and tables were prepared for each cable for use by the laying controller, relating the dynamometer tension required at any instant to the water depth for the speed of laying. The only modification to this simple procedure was over a short distance on the downward side of the ridge off Galiano Island, when it happened that the ship was sailing in water of constant depth while the cable was still moving down the slope. In this region, the tension was controlled by reference to the length of cable paid out.

During the laying, comprehensive records were obtained, including depth, dynamometer tension, ship's course and speed, length of cable paid out, straight-line distance travelled by the ship (from a taut-wire apparatus) and angle between the cable and the water surface. From the data obtained it was confirmed that the cables had been laid closely in accordance with the planned requirements.

The speed of laying was limited to approximately 3 knots, which was considered the maximum at which the cable could safely be handled out of the hold and through the ship's machinery. During cable laying, the ship's navigating officers plotted her position at four-minute intervals, using suitably positioned markers on land and, in the Strait of Georgia, additional marker buoys with radar reflectors, previously laid by the ship. Laying proceeded without incident, except for one Trincomali Channel cable, when the ship was carried at right angles to the route by an unexpected tide rip near Parker Island, and the cable under heavy tension rose up over the bow-sheave flange and was bent to a radius of 15in and visibly flattened. During d.c. testing, after laying, it failed at this point and a submarine repair joint was inserted.

Fault Location and Repair

From numerous tests carried out, the pneumatic resistance of the cable had been shown to be very uniform, and accurate formulæ were derived relating gas flow to the feed distance. The method developed for locating a submerged gas leak in a faulty cable consists of a loop test, using a sound cable, applying a common pressure and measuring the relative gas flows, and then applying the formulæ to calculate the fault position. Gas leaks in terminal equipment and cables above low water mark can be located by methods used for land cables. The location of electrical faults, in general, follows conventional practice as for land cables.

Means had been developed for locating and cutting a faulty cable in the maximum depth of water prior to lifting for repair, since it would be impracticable to lift a bight of cable of this type in any appreciable depth without cutting it. The test methods already referred to, used in conjunction with the record of cables as laid, would give a preliminary location which might be confirmed, using Leader gear[8] and by towing a submarine search coil to pick up a signal injected into the faulty cable. Grappling for the cable would then proceed in this area, using a specially designed grapnel containing a search coil (to confirm that the correct cable was in the prong of the grapnel) and an explosive charge to be fired from the surface for cutting it.[9] The gas system previously described would limit ingress of water and the two ends would be recovered separately for jointing-in the required new length of cable.

The fault previously referred to was located by the Hilborn[11] loop test, using other sound cables to complete the circuit, at a point some 600 yards from Parker Island in a depth of approximately 30 fathoms. The position of the fault made it possible to use a simplified repair procedure by cutting the cable near the foot of the chase and recovering it by scow to a point just beyond the fault position. A capacitor discharge was then used to give precise audible location of the fault in the cable on the scow deck. It was confirmed that the cause was severe local crushing. The scow which recovered the faulty cable also carried a length of repair cable, a submarine repair joint, and all the necessary materials and staff. A four-point mooring was required owing to tidal conditions and was provided by the ship's mooring buoys and two additional concrete clumps placed clear of the other cables. The faulty cable was cut out and the sound cable jointed to the repair length in approximately twenty-four hours by a team of jointers working continuously. The joint was lowered off the apron of the scow in line with the cable, the weight being taken by steel ropes to hand winches fixed on the scow. The repair cable was laid to the shore, the end being pulled to the terminal as for a starting end. It was later fully tested, both pneumatically and electrically, and made alive.

Gassing, Testing and Commissioning

The cables were charged with nitrogen to a pressure of approximately 10 lb per square inch before they were loaded into the cable ship and were checked on arrival in Vancouver. Immediately after laying and before the terminations were made, the cables were tested at 276kV d.c. for fifteen minutes at atmospheric pressure. After the terminations had been made, the cables were gassed at a rate of 50 lb per square inch per hour up to 350 lb per square inch for a pneumatic over-pressure test. The cables were then retested at 276kV d.c. for fifteen minutes, and as soon as the circuit was available, line voltage was applied for a period of approximately forty-eight hours. The cables were brought down to their working gas pressure of 300 lb per square inch and the pneumatic system was set to give the required warnings.

Operating Record

Since the submarine cable interconnection first went into official service on September 25, 1956, it has been in continuous operation except for a few short outages for testing and overhead-line maintenance. No operating problems have been experienced, except for a minor leak of the gas-pressure supply system at Tsawwassen Beach, which was remedied, and the interconnection has functioned satisfactorily and efficiently.

Recently, during unexpected outages of some hydro-electric plants on Vancouver Island, the submarine interconnection was called upon to provide additional peaking power from the mainland system. Thus, at a very early date, the cable has already accomplished its dual purpose of providing a stand-by supply as well as a normal source of power for Vancouver Island.

It is believed that the engineering advances, which have been described, now make practicable and economic the transmission of large amounts of electrical energy under water by means of submarine cables. Many of the engineering difficulties in the field of underwater power transmission have been overcome and it is likely that important applications will now develop. It is probable that progress will be further stimulated by the advances made in the field of high-voltage d.c. transmission.[10]

References

[1] Sayers, D. P., Laborde, M. E., and Lane, F. J., " The Possibilities of a Cross-Channel Power Link between the British and French Supply Systems," *Proceedings I.E.E.*, Paper No. 1657, S. March, 1954 (101, Part I, page 284).

[2] Davey, E. L., and Barnes, C. C., " The Cross-Channel Power Link," *Electrical Supervisor*, 1955, 35, page 103.

[3] Beaver, C. J., and Davey, E. L., " The High-Pressure Gas-Filled Cable," *Journal I.E.E.*, 1944, 91, Part II, page 35.

[4] Besly, J. C., and Higgitt, H. V., " The Recovery of Deep-Sea Cable," *Journal I.E.E.*, 1933, 72, page 160.

[5] Beaver, C. J., " Lead Cable Sheaths," *Electrical Review*, March 30, 1945, page 468.

[6] " The Cable Ship ' Ocean Layer,' " *Shipping World*, 1955, 133, page 399.

[7] " Improvements in or relating to Methods of and Apparatus for Laying Submarine Cables," British Patent Application No. 33,637, November, 1955.

[8] Lawton, C. S., " Electronic Aids to Ocean Cable Maintenance," *Western Union Technical Review*, January, 1950, page 22.

[9] " Improvements in or Relating to the Repair of Submarine Cables," British Patent Application No. 2538, January, 1956.

[10] Rusck, A., " High-Voltage Transmission Developments in Sweden," *Proceedings I.E.E.*, Paper No. 1854 S, June, 1955 (102 A, page 333).

[11] Greatorex, J. L., " Localisation of Faults in Underground Cables," *Engineering Bulletin*, Siemens Bros. and Co., Ltd., June-July, 1945, page 1.

Premiums for Technical Articles.—Premiums awarded by the Radio Industry Council for articles published in the technical press were presented recently at a luncheon at the Cafe Royal. Premiums of 25 guineas were given for each of the following articles: " Weather Avoidance with Airborne Radar," by P. L. Stride (*British Communications and Electronics*, April, 1956); " Particle Accelerators and their Application," by D. R. Chick and C. W. Miller (*British Communications and Electronics*, October-November, 1956); and " Klystron Control System," By R. J. D. Reeves (*Wireless Engineer*, June, July, August, 1956); " Two-Channel Stereophonic Sound Systems," by F. H. Brittain and D. M. Leakey (*Wireless World*, May, July, 1956), and " TRIDAC—a Research Flight Simulator," by J. J. Gait and J. C. Nutter (*Electronic Engineering*, September-October, 1956).

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

TRIALS ON THE WESTERN REGION

SIR,—I have read with great interest Mr. O. S. Nock's article on this subject, but I am in doubt about the reason for the remark " . . . the performance on the final day might be scarcely believable as a feat of hand firing by one man." It seems to refer to the handling of coal at 4210 lb per hour for about 128 minutes. This rate was, however, surpassed by some 40 per cent for over 2½ hours on a Chapelon 4-8-0 running on the Northern Railway of France in 1935. As this was a well-publicised effort (and there were other comparable ones by locomotives of the same class), it must be known to Mr. Nock and to everyone else interested in the subject. Why then the present astonishment ? Can it be some subtle form of anti-Swindon propaganda ? The fact is that none of the figures quoted in the article is in any way remarkable against the general historical background of the subject and if any comment is made on them, that one should, in honesty, be the first. A sustained drawbar horsepower of 1000, for example, should place no severe demand on a 34 square feet grate, and why it should lead to the suggestion (page 595) that 3000 h.p. should be thought of as a future standard is hard to distinguish.

The reference on page 596 to " back pressure . . . between the root of the blast pipe cone and the top of the chimney . . ." is very curious and without obvious bearing on quality of performance. The significant back pressure is surely that which opposes the motion of the pistons on the exhaust strokes. This can never be less than about 15 lb per square inch (atmospheric), but may be less than 20 for average running conditions with appropriate design of a single blast pipe.

W. A. TUPLIN

Beech Dell, Collegiate Crescent,
Sheffield, 10,
April 26, 1957.

TRACTION ENGINE RAILWAY LOCOMOTIVES

SIR,—Having been catching up on technical reading during the Easter holidays, I was very interested in your two articles, published early in February, on the subject of traction engine railway locomotives. I was very surprised that Mr. Abbott states that the number of Aveling and Porter locomotives had been supposed to be very many fewer than the 105 which have been traced. From what I heard in boyhood days, I would have supposed the number to have been considerably more, an uncle of mine, now deceased, having been apprenticed at Invicta Works early in the present century. Fig. 8 shows an example built for " Peters Brothers, cement manufacturers." I wonder if this was at the latter-day Peters Works of the British Portland Cement Manufacturers, at Wouldham, Kent, which, together with the neighbouring works, spelt, I believe, Margetts, operated an extensive 4ft 4in gauge railway. At the time of closure, at the end of 1925, five locomotives were owned, two reasonably modern orthodox 0-4-0 S.T.s, and three Aveling and Porter machines. One of these latter I never saw, and may have been the subject of your photograph. Of the others, one was a compound, which my grandfather, who worked at Peters, told me was " always causing trouble," and was kept as spare engine : I never saw it running. The remaining engine was fitted with one cylinder and was in daily use to and from the upper working face of the pit. Mr. Abbott does not appear to have found many examples of this type during his researches, as he only mentions one, although I gathered from my uncle that they were nearly as numerous as the compounds, at any rate, up to about 1906. The principal difference in external appearance between the two types, apart, of course, from the cylinder arrangement, was the addition of a second flywheel on the right-hand side, outside the spur wheel, on the stud shaft.

My impressions about the numbers built may, of course, have been entirely erroneous, and I may add that although I lived all my life until the beginning of the last war in West Kent, I had no idea, until reading your articles, that either the Dunton Green or Borough Green brickworks had ever owned a locomotive of any of these types.

A. L. LAMBERT, Capt.

Welwyn Garden City,
Herts.
April 23, 1957.

Book Reviews

The Analysis of Engineering Structures. Third edition. By A. J. S. PIPPARD and J. F. BAKER. Edward Arnold, Ltd., 41, Maddox Street, London, W.1. Price 60s.

THE reappearance of this well-known and established book will undoubtedly be welcomed by a large circle of engineers acquainted with it. In its up-to-date form and with the admirable clarity of presentation maintained *Analysis of Engineering Structures* is assured of an ever-widening circle of users, both as a students' textbook and as a valued reference on the bookshelf of a practising engineer. The scope of the book cannot be better summarised than in the words of the authors in the Preface to the first (1936) edition : " The primary object of this book is to present to the student of engineering a general outline of the theories upon which the design of structures is based. Problems of practical design have been excluded as we believe that this side of the engineer's work cannot be effectively taught by means of textbooks and must be acquired by experience in the shops and drawing-office. This point of view explains the omission of certain sections commonly found in books dealing with the theory of structures, but we hope that such omissions will be compensated by the inclusions of methods of analysis which are not usually given and which in some cases appear for the first time."

The aim thus outlined is achieved skilfully. The elementary subject matter, treated generally in Strength of Materials textbooks, is presented adequately, but in the briefest possible outline. At the same time, problems of detailed design are touched upon only in the fields where they affect the principles of structural analysis, as, for instance, in the consideration of steel-framed buildings. In many of the items discussed the authors have done the original pioneering and exploratory work, and the occasional details of these investigations, together with historical notes, give vitality and lift the work out of the ordinary run of textbooks.

The new edition is considerably revised and rewritten. Now contained in twenty-two instead of twenty-four chapters, the subject matter covered is virtually the same as in the previous editions. Major deletions are apparent only in the chapters dealing with steel-framed structures and the application of the plastic design theory. These are justified by the appearance of the recent texts dealing with these matters in much greater detail (Vols. 1 and 2, *Steel Skeleton*, J. F. Baker), but a slightly fuller treatment of the plastic theory might have been desirable even if some other subjects might have had to be " pruned."

Chapters 1 to 10, 12, 14 to 15, and 17 deal in considerable detail with the various methods and applications of elastic theory to the problems of beams, frames, arches and struts. The moment distribution method previously dealt with partially in two chapters is now described and developed more fully and presented in one section. This arrangement is much more logical and complete. It is perhaps a mistake that the treatment of the column analogy method, incorporated for the first time in this edition, has been dealt with in the same chapter. We are of the opinion that this could have been more happily included in the chapter treating stiff-jointed frames, where it would quite logically follow the application of Castigliano's principles. In this connection a mention could have been made of the elastic centre method, which, though essentially identical, has some features of pedagogic interest. Chapter 11, dealing with the principles of reinforced concrete, has been largely rewritten and discusses mainly the basic principles of design. Reference is made now throughout to the current B.S. Code of Practice. The treatment is excellent for gleaning the basic principles involved and would allow a student to study more specialised works with complete understanding. A short mention of the principles of prestressing could perhaps have been incorporated without increasing the length unduly.

Chapter 13, on suspension bridges, has been modified only slightly. However, for some reason not clear to us, this has now been made to precede the chapter dealing with influence lines. As the definition of their meaning appears for the first time in the latter chapter some confusion may arise in the use of influence lines for suspension bridges for an uninitiated reader.

In the remaining chapters, where the extent of rewriting is considerably more noticeable, various subjects are dealt with. The section dealing with Professor Pippard's classic investigation into voissoir arch action

has been somewhat abbreviated, preserving nevertheless its completeness and interest. The treatment of masonry dams has been brought up to date by a presentation of recent research results on the subject. Those who have read Professor Pippard's "Unwin Memorial Lecture" (Institution of Civil Engineers, 1949) will appreciate the full implications of the historical developments described. It is observed that although uplift pressure effects have been described they are not incorporated in any of the examples quoted. This is a pity, as a wrong impression of their paramount importance may be obtained by a student. A brief treatment of the arch dam problem is now added. A completely new chapter has been written on the subject of earth pressures. This, according to the author's Preface, is at least in part due to Dr. A. W. Bishop from Imperial College, a well-known worker in the field of soil mechanics. This section, which, in its original form, was far behind the advances of the science of soil mechanics, now presents results and methods not available yet in standard textbooks of the subject. The treatment of both active and passive pressures in cohesive and non-cohesive soils is given, and while the emphasis is mainly on pressures developed on rigid walls, an indication of the treatment of flexible pile walls is very adequately presented.

The new edition retains the old format and excellence of printing. It is impossible in a work of this magnitude to correct all misprints, even with the most careful proof reading, but their number appears quite insignificant.

Technical Aspects of Sound. Volume II: Ultrasonic Range, Underwater Acoustics. Edited by E. G. RICHARDSON, B.A., Ph.D., D.Sc. Cleaver-Hume Press, Ltd., 31, Wright's Lane, London, W.8. Price 70s.

IT is not many years ago that we had to rely on Rayleigh, Lamb, Crandall and Morse as authors of text-books of theoretical aspects of sound waves and vibrations, which might have practical, technical or engineering applications; the last source-book was by Bergmann just before the war. The present text is a great advance on these, backed by the life-time's experience of Professor Richardson, who not only co-ordinates contributions from home and abroad but provides two chapters himself, in which he draws on original scientific work and the faculties of both teaching and writing. The result is admirable.

It would not be fair to say that the text is but a review of the many hundred references attached to each section. Each writer has applied a critical faculty and made the whole greater than its parts, and clearly states where the art of scientific analysis has arrived to-day. One can but briefly glance at the table of contents. First is considered the propagation of sound in the atmosphere and the sea. One next observes the transducers which transmit and receive waves in these media, with specific applications, including medical; one presumes that many of these are still under security. A special section is devoted to measurements, but precision of measurement is inherent in the whole work, in spite of the wavelength difficulty which often leads to empirical approximations. Absorption by resonators and specially developed surfaces is linked to accurate measurements, since they contribute to defined waves, free from reflection influences. Bubbles and cavitation are also made of importance.

A special division comes from American authors who have studied both propeller noise and jet engine noise, subjects which have hardly been touched on in this country. The problem of any aircraft noise is very serious because of the disturbance to those who are not particularly interested in air transport, and such considerations should be taken into account when siting aerodromes near urban areas. Air transport between city centres, however desirable, is naturally hindered by the necessity for space for aircraft movements and the associated hazards; the proposed use of helicopters turns our attention to them and particularly to the threat of blade-tip ram-jets, which are very noisy indeed.

Power System Communications. Edited by E. OPENSHAW TAYLOR, B.Sc., M.I.E.E., George Newnes, Ltd., Tower House, Southampton Street, London, W.C.2. Price 35s.

THIS book, like its predecessors, *Power System Transients* and *Power System Plant*, deals with a specific aspect of power system operation and is based on a series of advanced lectures at the Heriot-Watt College, Edinburgh. The purpose of these lectures was to acquaint practising engineers with modern developments and trends in power station practice. The book now under review covers methods of communication by speech and signals between various points in a power system. These methods involve telephony and various kinds of supervisory control, including remote operation of equipment from a central point and telemetering (the transmission of switch conditions or instrument indications to a remote point). The transmission of signals appertaining to automatic protective gear is also included. To cover this ground the book contains chapters on communication circuits, Post Office plant, carrier-current equipment, radio and television apparatus, supervisory control, telemetering and intertripping. A useful appendix on graphical symbols is included.

Engineering Uses of Rubber. Edited by A. T. MCPHERSON and ALEXANDER KLEMIN. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 100s.

THE subject matter of this book has been contributed by eighteen rubber technologists and covers practically the whole field, so that it forms a link between the manufacturer and the engineer user. The various chapters deal with reasons for the use of rubber and how it is employed, and indicate how the data given can be applied to the solution of problems and to the development of new techniques. The book, which contains much unpublished information, is of value to engineers and technologists, both inside and outside the industry. There is material of interest for civil, chemical, electrical and mechanical engineers: sections of the book discuss design of rubber mountings, rubber in automobiles, rubber and aviation, tyres and belt conveyors. Other chapters touch upon the general engineering properties of rubber, specifications and inspections and the different synthetic rubbers.

Mathematics. By A. T. STARR, M.A., Ph.D., M.I.E.E. Sir Isaac Pitman and Sons, Ltd., Kingsway, London, W.C.2. Price 45s.

ANOTHER of this publisher's Engineering Degree series, this book covers the syllabus of Mathematics, Parts 1 and 2, for the University of London examination, from papers of which examples are taken. An elementary treatment of operational calculus is given by the method of the Laplace transform.

Books of Reference

Ship and Boat Builder Annual Review, 1957. John Trundell (Publishers), Ltd., Temple Chambers, Temple Avenue, London, E.C.4. Price 40s.—The review opens with articles dealing with the small shipbuilding industry in Holland, Sweden and Germany, shipbuilding techniques and developments in plastic construction, followed by a description of the ship research facilities at N.P.L., an appraisal of Soviet naval strength and an examination of the export problems of marine engines. Other articles refer to air-cooled engines and cargo handling in coasters and there are a number of illustrations of small craft built in 1956. There is a directory of British Builders and Repair Yards, able to handle craft up to 1000 tons gross, which gives particulars of facilities. In this the yards are arranged in alphabetical order and there follows an index in which the yards are grouped geographically, while overseas builders are listed under their respective countries. In the engine section marine engine specifications are tabulated, there being a separate group for outboard engines, followed by a list of spares and servicing depots. Another section of the annual deals with paint manufacturers and paints, the manufacturers and suppliers of marine fittings, materials and yard equipment, and ship and boat-building timbers. Additional directories are concerned with consultants, associations, British owners of small craft, dock and harbour authorities, British yacht clubs and commercial diplomatic officers and trade commissioners.

Hütte IV A. Elektrotechnik, Teil A. Starkstromtechnik und Lichttechnik. Twenty-eighth edition. Published by Akademischer Verein Hütte e.V., Berlin: Wilhelm Ernst and Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, German Federal Republic. Price (cloth) DM.39; (leather) DM.49.—In previous editions of this well-known German reference book for engineers, electrical technology was dealt with in a section of Vol. II, "Mechanical Engineering." The enormous growth of this field is reflected in the fact that in the new twenty-eighth edition, electrical engineering is treated in two separate volumes, Hütte IV A, *Electrical Power*, and Hütte IV B, *Telecommunications*. In the present volume full attention is paid, not only to the electrical aspect of a multiplicity of designs, but also to the mechanical calculations involved. Properties of insulating materials, dielectrics, certain metals, materials for contacts, and ferromagnetic materials, are collected in a large number of tables. Abstracts from the most important German standards are quoted and German and foreign circuit symbols are listed.

The British Shipbuilding Compendium, 1957. The Shipping World, Ltd., Effingham House, Arundel Street, Strand, London, W.C.2. Price 20s.—The seventh edition of this compendium incorporates all the changes made in the previous edition together with all the latest available information. There are four main sections preceded by an index of headings, which includes ample cross references, and followed by an index of firms which is of assistance in ascertaining the range of products of any particular firm. Section "A" is subdivided into four groups in which are listed the relevant particulars of the builders of ocean-going ships, coastal and smaller ships, and of small craft, together with information concerning ship repairers and drydock owners: Section "B" contains similar data with regard to the various forms of propulsion machinery. In Section "C" are included the names of manufacturers of the wide range of auxiliary fittings and items of ship outfit, while the makers of shipyard equipment are listed in Section "D."

Books Received

Bandstrassen im Baubetrieb. By Heinrich Eckert. Springer-Verlag, Berlin, W.35. Price DM.37.50.

Rilem Symposium on Winter Concreting. Concrete Publications, Ltd., 14, Dartmouth Street, London, S.W.1. Price 65s.

Realities of Space Travel. By L. J. Carter. Putnam and Co., Ltd., 42, Great Russell Street, London, W.C.1. Price 35s.

Induction and Dielectric Heating. British Electrical Development Association, 2, Savoy Hill, London, W.C.2. Price 8s. 6d.

Modern Techniques of Excavation. By Herbert L. Nichols. Odhams Press, Ltd., 96, Long Acre, London, W.C.2. Price 70s.

The Manufacture of Iron and Steel. Volume I, Iron Production. Second edition. By G. Reginald Bashforth. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 45s.

British Industries Fair

THE British Industries Fair will be opened at Castle Bromwich on Monday next, May 6, and will be open daily until Friday, May 17. The information we have received to date indicates that the number of exhibits of primarily engineering interest will be limited this year, and the following notes on industrial equipment have been prepared from preliminary particulars received from some exhibitors.

Amongst the firms showing sheet metal working equipment will be the Bronx Engineering

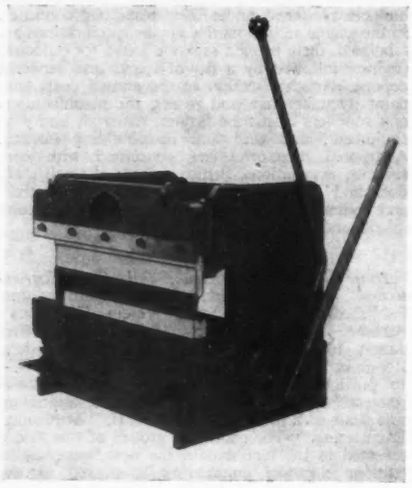


Fig. 1—Hand-operated press brake with 24in-long beams and a 2in stroke—Bronx

Company, Ltd , of Lye, Worcs, which is exhibiting a 60-ton press brake, a hand-operated press brake and a three-roll pyramid plate bending machine for work up to 10ft wide by ¾in thick. The large press brake and the bending rolls are typical of this firm's machines, which have already been described in our columns, but the hand-operated machine is probably less familiar. This small press brake is of steel plate construction and has a beam length of 24in with a clear distance of 17in between the housings. Its top beam has a stroke of 2in and the bottom beam adjustment is 2in.

As can be seen from the illustration in Fig 1, the side frames of the machine are rigidly tied together by a deep-section front support plate and top and rear cross members. The deep-section top beam has phosphor bronze shoes on each side, which work in circular steel slides on the side frames. The bottom beam is mounted on screw jacks, through which its height is adjusted. Two hand levers are fitted for turning the ball bearing-mounted crankshaft, the long lever being used for bending light gauge material. The short lever, which operates a ratchet gear, is used when working on heavy gauge material.

The press equipment of Turner Brothers (Birmingham), Ltd., Cleveland Street, Birmingham, 19, will include five examples of the firm's power presses of from 6 to 70 tons capacity. and the three-stage, single-wing, tangent bender shown in Fig. 2. This press has been designed and built by the firm for the manufacture of refrigerator evaporator trays 11in wide and of varying lengths, as can be seen from the examples in front of the machine. The press is loaded with components, two at a time, and they are clamped by a hydraulic cylinder, which applies a load of some 13 tons to prevent distortion of the plates during the bending operation. Bending is effected by the rolling action of the wing against the forming dies, the rolling action of the wing preventing any flattening of the preformed sheet.

The group of moulding presses, hydraulic equipment and other plant, of Fawcett-Finney, Ltd., Berkley Street, Birmingham, 1, will include the wire take-up machine illustrated in Fig. 4, which is designed to handle reels from 24in to 40in flange diameter and 25in overall width. This machine is arranged for wire speeds of up to 2000ft per minute and reeling is continuous and automatic, including transfer of wire from reel to reel and cutting between reels. The changeover of wire when a predetermined length has been wound on one reel is effected by a wire-measuring machine, or push-button control. The reel drive is electrically synchronised with the capstan speed by a tachometer generator, and main drive to the reel arbors is by multiple

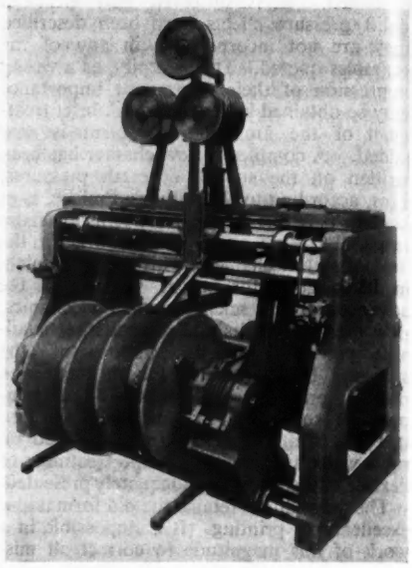


Fig. 4—Continuous reeling wire take-up machine for wire speeds up to 2000ft per minute, equipped for automatic transfer of wire from reel to reel and cutting between reels—Fawcett-Finney

V-belts. Reels are raised pneumatically to their running position on the machine, and an automatic brake stops a full reel as it is lowered to the floor.

The traverse mechanism of the machine incorporates two variable pitch diameter pulleys

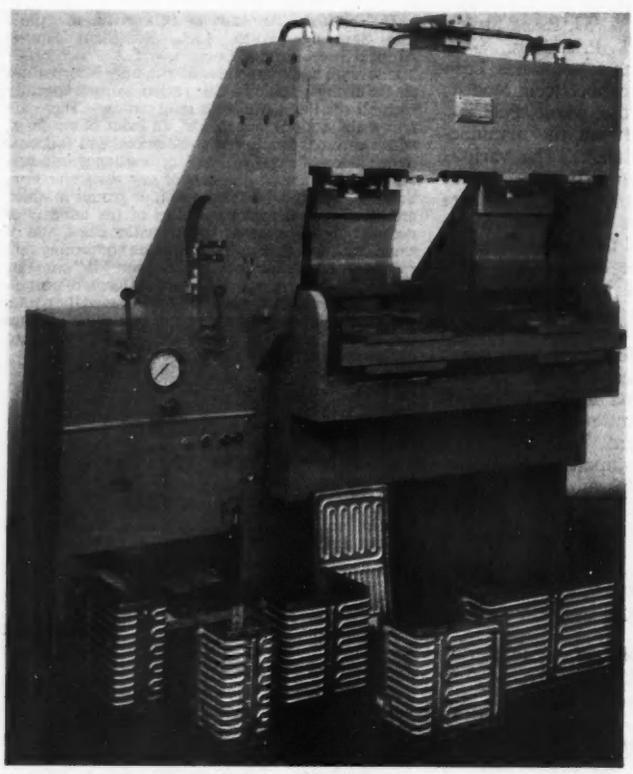


Fig. 2—Three-stage, single-wing, tangent bending press equipped for the bending of refrigerator trays—Turner

Fig. 3—Electrically-heated holding furnace for molten metal, with automatic feed to die-casting machines—Birlec

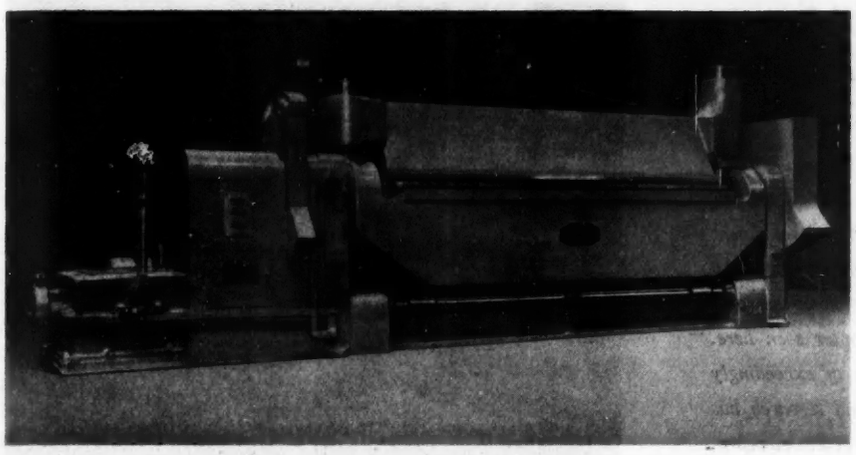


Fig. 5—Bending and folding machine for mild steel plate up to 8ft long and ¼in thick—Scottish Machine Tool

which provide infinitely variable lay adjustment whilst the machine is running, instantaneous traverse reversal being actuated by adjustable trip dogs. A quick-traverse shift between reels starts a new wind just inside the inner flange of the new reel. Constant wire tension is provided by an integrally mounted, pneumatically-controlled accumulator which is adjustable to impart a load from 5 lb to 40 lb over the full double-arm movement.

An exhibit of interest on the stand of the Midlands Electricity Board will be the "Ajaxomatic" holding furnace of Birlec, Ltd., Tyburn Road, Erdington, Birmingham, 24. This design of furnace can be used for holding molten aluminium or zinc alloy supplies and feeding the metal in predetermined quantities to die-casting machines. Molten metal is supplied to these furnaces from an auxiliary source. One of the furnaces is illustrated in Fig. 3. It is rated at 20kW and has an average power consumption of 10–12kW; the useful molten metal capacity being 300 lb and the pouring rate about 2 lb per second. From ½ lb to 10 lb of metal can be delivered per shot with this equipment.

In terms of the required electrical supply, the "Birlec-Ajaxomatic" is similar to the well-known "Birlec-Tama" mains-frequency melting furnace. It employs a coil supplied with alternating current from normal frequency mains and is equipped with an iron core to concentrate the magnetic field. This field also passes through part of the furnace charge, which acts, in effect, as a short-circuited secondary winding of a transformer, carrying a heavy induced current. The particular feature of this method is that heat is generated within the charge and is not imparted to it from an outside source. The molten metal in the bath is thermostatically controlled at the required temperature. A standard refractory lining as used for aluminium melting is employed in the holding chamber.

The lid of the furnace is sealed so that metal can be discharged as required by the introduction of compressed air above the melt. When air is admitted a quantity of molten metal is forced through the pouring spout from a point below the surface, the quantity discharged being regulated by the duration of the compressed air flow. An automatic device compensates for the difference in volume within the holding chamber caused by each successive shot.

The control panel of the furnace is divided into two sections, one of which contains the standard temperature regulators and furnace controls. The second section, besides incorporating the timing controls to regulate the compressed air supply, also has an automatic device that controls a supply of heat to the pouring spout, which is essential to prevent the molten metal from chilling during discharge.

The heavy equipment shown on the stand of the Scottish Machine Tool Corporation, Ltd., will include the Craig and Donald universal folding and bending machine illustrated in Fig 5. This machine is capable of bending or folding 8ft long mild steel plate ¼in thick, and is fitted with a swing-out top beam to facilitate removal of enclosed shapes or trunking. Another exhibit on the same stand will be a set of Bennie plate bending rolls for mild steel plates up to 8ft wide and ¼in thick. This machine is driven by a continuously running motor through two sets of friction clutches, one set for controlling the operation of the lower rollers, and the other for raising or lowering the top roller. The machine is erected on two steel beams, the top surface of which are machined to accommodate standards, gearbox and motor. The end bearing of the top roller is of turn-down design, arranged for easy operation when removing complete tubes from the machine. The machine is driven by a 24 b.h.p. motor and is complete with an oil-immersed, star-delta starter, having no-volt and three overload releases.

A new flameproof electric fork truck developed by Conveyancer Fork Trucks, Ltd., Warrington, has all the electrical equipment situated in flameproof enclosures constructed according to the requirements of B.S.S. 299. The external wiring between the electrical components comprises mineral-insulated, copper-clad cables; screwed flameproof glands house and protect the sealing termination. This truck has a capacity of 4000 lb at 20in load centres and a 4500 lb capacity model is also being introduced.

The Technograph Electronics Products, Ltd., 32, Shaftesbury Avenue, London, W.1, is to show samples of assemblies on printed circuit boards (for television and radio receivers) with their counterparts manufactured by the older wiring methods. Flexible backed foils will illustrate some of the uses of the new techniques, both in wiring forms and in various heating devices and resistive patterns. Double-sided boards will show the application to computer work, for which purpose also complex switching plates will be seen, and circuits including resistive, capacitive and inductive elements. This firm has developed a technique of flush bonding the contact surfaces of the "digitiser" plates and commutating devices so that a smooth track is obtained for any bush gear. Examples of different finishes will be shown, such as silver and rhodium for switch contacts.

An "Efco-Udylite" fully automatic plating plant is to be shown in operation by the Electro-Chemical Engineering Company, Ltd., Weybridge, Surrey. This plant incorporates a system of chainless transfer by means of reciprocating pushers on the overhead track, and it is suitable for nickel, zinc, cadmium or tin plating. In it the automatic transfer of work from tank to tank is effected by a lifting frame incorporating a cathode track from which the racks are suspended and a synchronised secondary pusher mechanism which moves the racks horizontally. The mechanism operates at every time cycle. At each traversing operation the racks are moved forward one stage, either to the next tank or while still submerged, according to the process. A considerable degree of variation in immersion times is possible and the time taken for the transfer of racks from one tank to the next is twenty-six seconds. An adjustable time clock is provided by means of which the speed of the machine can be varied over a wide range.

Normally, an oil hydraulic drive unit is provided for driving the transfer mechanism, and it is complete with an electric motor and oil pump and reservoir, combined in a floor-mounted panel, with the contactor and control gear. For certain applications pneumatic drive equipment is provided for the plant.

Alfred Bullows and Sons, Ltd., Walsall, will show a representative range of "Hydrovane" compressors with capacities from 3 to 250 cubic feet per minute. An experimental gas turbine driven compressor has been built for development work, and it consists of a 60 b.h.p. Rover gas turbine driving one of the firm's sliding vane rotary compressors. The turbine runs at 46,000 r.p.m. and an integral gearbox reduces the speed to 3000 r.p.m. at the take-off shaft. Bleed-off air at 3 atmospheres is taken from the centrifugal compressor of the gas turbine and, after cooling, is fed to the compressor, which, in turn, raises the pressure to 100 lb per square inch. At this pressure the compressor delivers the air at about 300 cubic feet per minute. Although this plant is experimental it is pointed out by the firm that it weighs only about 500 lb—only a fraction of that of a conventional equipment of 300 cubic feet per minute capacity.

In addition to a representative selection of fans and industrial gas equipment, Keith Blackman, Ltd., Mill Mead Road, London, N.17, will show one of the Mark II "Keno" filters. This industrial wet washer is designed to remove finely divided contaminants from the air streams from equipment such as paint booths, polishing machines, foundry knock-outs, and flues. Its general construction can be seen in Fig. 6. It

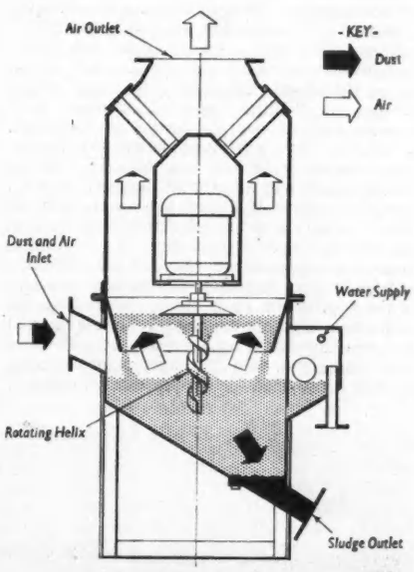


Fig. 6—Arrangement of industrial wet washer for the removal of contaminants from air streams—Keith Blackman

comprises a water tank, a helix direct driven by a squirrel-cage motor, and a set of moisture elimination plates, all contained within a bifurcated outer casing of square cross section. In operation, the water is elevated from the water or sludge tank by the rotating helix, above which is a deflector plate. This plate discharges the water at high velocity in the form of a solid curtain across the path of the air stream, thus ensuring thorough wetting and separation of the particles. Any water carried over with the air from this zone is removed by the eliminator plates fitted in the top section. These eliminator plates are accessible through openings fitted with quick release doors and each individual plate can be removed for cleaning. Water from the main curtain drains back to the sludge tank, from where it is re-elevated to repeat the cycle. In draining back, this water forms a second curtain, this time over the inlet to the unit.

Rotor Tip Pressure Jets

The principle of propelling lifting rotors by supplying compressed air to burners at the blade tips and exhausting tangentially has been the subject of extensive development work by Fairey Aviation. This system, which reduces the torque reaction on the airframe to the friction in the rotor head, is used in the "Ultra Light" helicopter seen here. For larger machines, combustion chambers of exceedingly high heat release rates have been evolved, and research has been done on reducing the noise of the jets as described below.

THE combustion of air in burners at the blade tips of a helicopter rotor presents stringent problems since, in addition to the efficiency and pressure loss, both the weight and the envelope are critical in a chamber moving at a high subsonic Mach number and suffering a very high acceleration. The Fairey Aviation Company, Ltd., has done much interesting research work on these problems at its pressure jet test site at White Waltham. As usual in combustion research, the establishment is dominated by its air compressors, which, in this case, are a Napier "Eland" 151, providing air for "Rotodyne" burners, and a Rolls-Royce "Dart" 506, whose compressors are bled in the same manner as that of the Blackburn-Turboméca "Palouste" which powers the "Ultra Light" helicopter. Both engines are, of course, devoid of airscrews. Each plant has a separate building, that for the larger engine being fully soundproofed with air intake splitter and an exhaust detuner. In each case the building is shaped like an H, with the engine in one upright and the cross-piece housing the settling length of duct required for accurate mass flow measurement. Beyond the calibrated orifice the duct resembles the internal passages of the appropriate rotor blade, and ends in the tip burner. Since the cooling effect of the external air flow is absent, the burner is sprayed with water when under test. On the larger plant a second detuner is provided for the pressure jet exhaust.

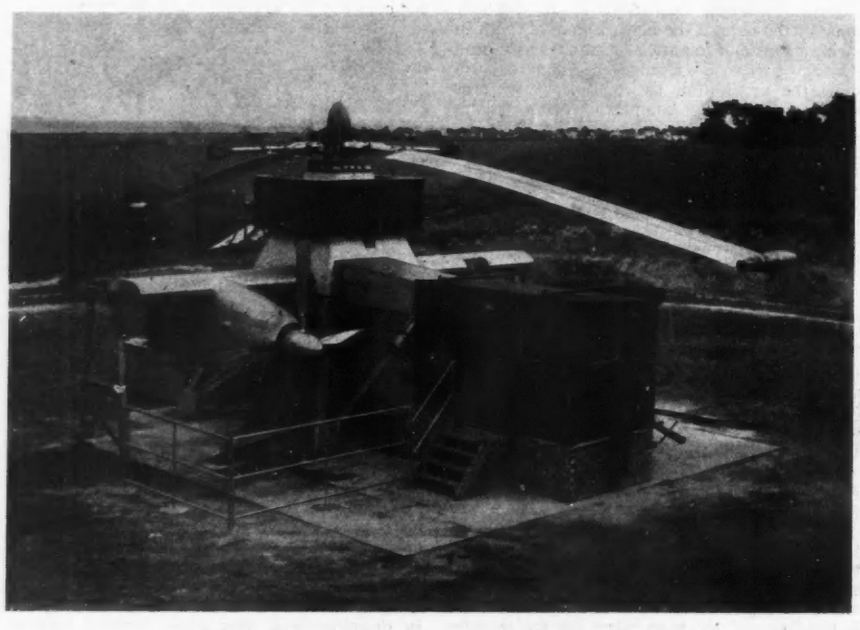
In each case the air is alternatively directed to a second test rig; for the "Eland" engine this is a spinning rig for the "Rotodyne" rotor, and for the smaller engine a noise suppression test rig. The former consists of a pylon, braced by eight steel cables, standing in the centre of a circular screen of torpedo netting. On the pylon is mounted a "Rotodyne" hub of the original five-bladed design, carrying one blade and two balance weights in the stations furthest from the blade. The blade is rather shorter, and the angular velocity slightly higher, than on the actual aircraft, because of the restricted radius of the rig; tip speeds of 650ft per second, corresponding to accelerations of 320*g*, can be attained. At the foot of the pylon is a cabin, in radio communication with the "Eland" control room, in which the air and fuel controls and the instrumentation for the rotating blade are housed; pressures and temperatures are reduced to d.c. voltages by transducers and taken off the blade by fifteen sliprings. The thrust of the jet is measured with the blade stationary and the chamber cooled by water sprays, and subsequently deduced from pressure measurements when the blade is rotating. To allow full thrust to be developed without generating an unbalanced lift, a drag plate is attached to the blade inboard of the tip. The latter rig consists of a pressure jet mounted on a thrust measuring rig set up on the aerodrome and surrounded by a clear 100ft radius circle with 15 deg. intervals marked around the perimeter. For noise level tests the total sound power at each of these points in turn is measured by test gear on a small trolley.

To make a realistic test of the complete power unit of the "Rotodyne" a special spinning rig, seen in the accompanying illustration, has been erected at Boscombe Down; at present only one engine, providing enough air for two blades, has been installed. On this rig the fuel, oil, starting and pitch controls are all exactly similar to those of the aircraft.

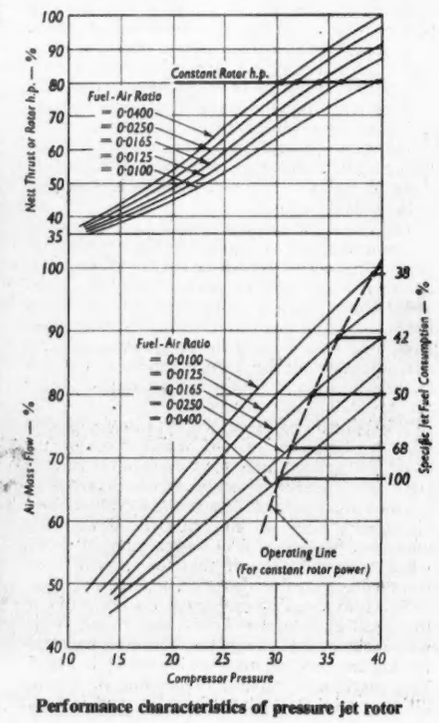
Combustion chamber development work has also been carried out at the National Gas Turbine Establishment, in particular by the use of water carrying visible particles to simulate at a greatly reduced speed the flow of gas through a combustion chamber. A transparent model built for this purpose can be seen in one of the illustrations.

Combustion Systems

Two forms of combustion chamber have been developed—one flat and one cylindrical. The flat one is intended to form part of the aerofoil, and hence lies radially in the blade, the exhaust gases being turned 90 deg. to the nozzle.



"Rotodyne" propulsion system test rig at Boscombe Down

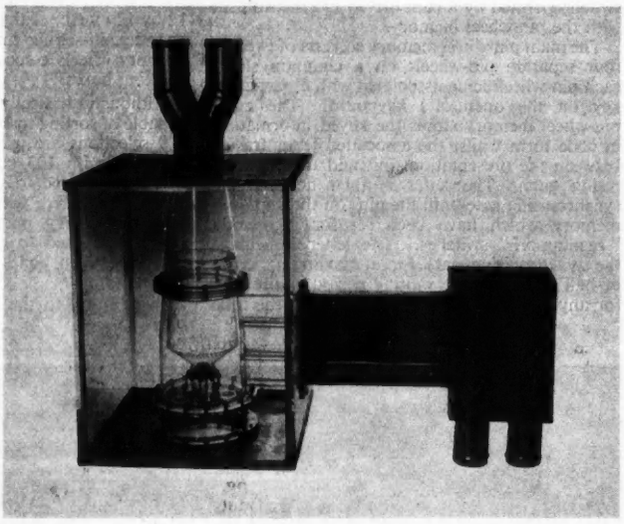


Performance characteristics of pressure jet rotor

Chambers of this pattern are used on the "Ultra Light" helicopter, and at present develop up to 60 lb thrust. The outer casing is welded up from stainless steel, although Nimonic alloy may be used in later machines. The flame tube is also flat, and the sprayer gives a flat jet of fuel 100 deg. wide; this is achieved by, in effect, developing two inclined jets which impinge immediately in front of the nozzle and have zero momentum in the planes of symmetry. The flow number of these nozzles is only 0·3, so that the manufacturing tolerances are exceedingly small. There is a fixed igniter in each chamber. The combustion intensity is of the same order as in gas turbines, and either petrol or kerosene can be burnt.

The circular chambers used on the "Jet Gyrodyne" and under development for the "Rotodyne" are easier to manufacture and better able to withstand internal pressure, although those of the "Gyrodyne" were found to grow oval under the combined effect of temperature and acceleration. It is found, however, that if a satisfactorily symmetrical air flow through the chamber is to be achieved, the pressure loss is usually high; it is desirable for the mass of the chamber to be in line with the axis of the blade, and, hence, the chamber has by no means the elbow configuration sometimes seen on industrial engines. In these chambers the combustion intensity is exceptional, around 12×10^6 C.H.U. per cubic foot per hour, and the exhaust temperature is about 2000 deg. Cent.; they have been run on kerosene and low and high-octane gasolene.

To avoid further development work on the engines and auxiliary compressors, no control of air delivery other than engine speed and the filling and emptying of the coupling is provided. Hence, the combustion chambers must be lit up with an air flow rather greater than that at full power. An igniter location has been found which allows this to be done with a high energy discharge rather than a torch igniter. Since the current to the igniter must be fed along the whole length of the blade—the coils are mounted at the root and supplied through slip rings—it is undesirable to insulate the conductor heavily and a form of igniter has been evolved by Napier which breaks down at the unusually low voltage of 500 and sparks several times a second. The surface across which the discharge occurs is coated with a semi-conductor about 0·008in thick which reduces greatly the voltage needed to initiate the discharge, and the capacitance component forms the arc. Each discharge dissipates about two joules. Lighting up is performed at a mixture strength richer than stoichiometric and, at least if the rotor is at rest, announced by a puff of flame. The chamber runs with a ragged blue flame, rising to pale grey at full fuel.



"Perspex" model combustion chamber for flow visualisation using water

Propulsion Problems

Pressure-jet propulsion is, compared to turbine drive, inherently noisy, reaching possibly 115 db above the audible threshold at a distance of 200ft. It is desired to reduce this by at least 10 db, which will mean that the noise is only slightly greater than for a conventional helicopter; since, for a given installed power, the "Rotodyne" climbs away much faster, this will result in a great deal less nuisance, the convertiplane being about 20 db down on the helicopter one minute after take-off. Since the blades themselves run at about 95 db, reductions below this level, even if possible, would be of little value.

A large variety of nozzles have been tested, with the usual finding that orifices with very large perimeters give the most suppression. Serrated nozzles were found to be of little value. It is expected that the 10 db reduction will entail 5 or more per cent loss in thrust, and need a nozzle much greater in overall dimensions than those illustrated.

The pressure for the fuel sprayers, about 1000 lb per square inch, is developed by the acceleration field along the blade. The rotor is flown, when the burners are lit, at a constant Mach number for the advancing blade, which, since the jets are extinguished at about 80 knots, is very close to constant rotor speed. The characteristics of a pressure jet rotor system at constant speed are shown in the accompanying graphs; they show in striking fashion how powerfully the use of tip burning reduces installed power, but at a sharply increasing cost in fuel consumption.

The table below shows a comparison between the performance of this system and the two other most favoured forms of reactionless rotor drive.

Comparative Size and Performance of Tip Jets for the Same All-Up Weight of Aircraft

	Max. cross sec. of jet	Disposable load	Spec. fuel consumption	Maximum endurance
1. Pressure jet	1·0	1·00	1·0	1·00
2. Pulse jet	5·2	1·48	2·5	0·77
3. Ram jet	9·2	1·50	3·6	0·48

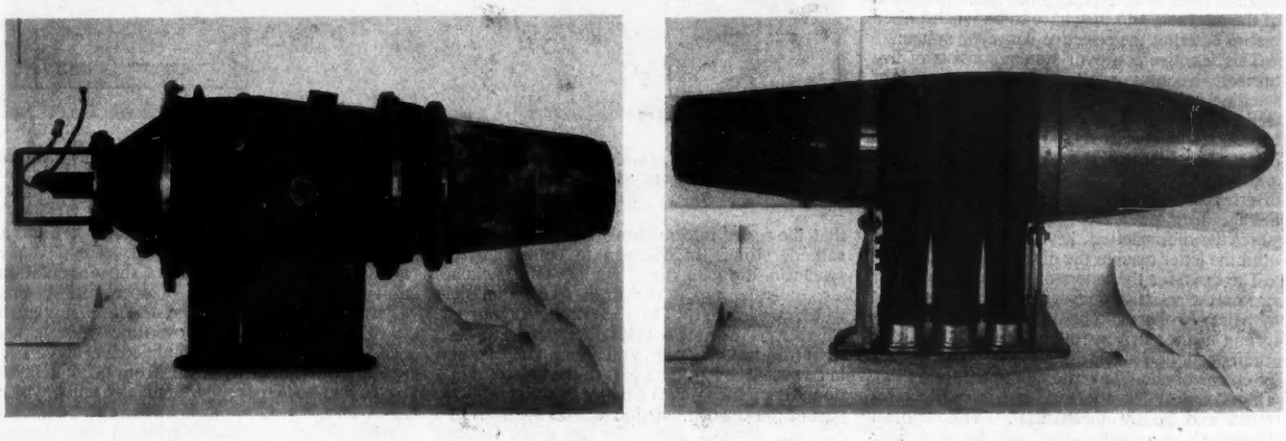
The cross section of the jet gives a guide to the size of the blade tip units. If this figure is reduced to zero, i.e. mechanical drive from engines in the hull, there will be further reductions in specific fuel consumption and, in all probability, disposable load.

The principle of the "Rotodyne" was described, and a model of an early design illustrated, in our issue of Sept. 19, 1952, page 377. Accounts of the "Jet Gyrodyne" and "Ultra Light" machines in flight appeared on Sept. 9, 1955, page 372. The Napier "Eland" E.151, with auxiliary compressor for pressure jet propulsion, was described and illustrated on page 408, Sept. 16, 1955.

Fuel Efficiency

At a meeting of the Institute of Fuel held in London on April 24, Mr. J. R. Rylands delivered his presidential address, entitled "Fuel Efficiency." In the matter of economic fuel utilisation, Mr. Rylands suggested that fuel could be classed as "consumer goods," so that the producer benefited by high consumption, whereas the consumer benefited by efficiency in its use. He went on to say that whereas science was concerned with the acquisition of knowledge, its application was a matter of technology, and from this general conception he made the point that technology and ethics were closely linked.

Returning to the subject of fuel efficiency, Mr. Rylands commented that the earlier incentive—that of personal gain, to effect economies—in the era of cheap fuel, had lost force due to heavy taxation and the trend towards large industrial groups. In earlier days fuel economy equipment was fitted on the basis of it giving a good return in the investment; however, continued the president, to-day heavy taxation left very little of the gross profit either for reinvestment or for the shareholders. Mr. Rylands recalled that Sir Oliver Lyle, discarding personal gain as an incentive, advocated the imposition of a heavy duty on fuel to encourage economy, but he felt that this would only mean that costs would just be passed on, particularly in the nationalised and the amalgamated industries. Since rising fuel costs seem to be linked with inflationary tendencies, Mr. Rylands thought that the reverse might apply and suggested a subsidy to reduce the price of fuel and so in turn lower the cost of power, transport and manufacturing prices generally.



Experimental (left) and final forms of "Rotodyne" chamber. The initial design was made in sections for easy modification, and used for rig tests only. The mountings of the final chamber are for test purposes only

Mechanised Sorting Equipment for the Post Office

For several years the postal authorities in this country have been investigating ways and means of introducing a greater degree of mechanisation to reduce manpower requirements and hasten services. The prototypes of two interesting machines developed as a result of these investigations, which we describe below, were demonstrated to the Postmaster-General, Mr. Ernest Marples, a few weeks ago at Southampton. One of these machines sorts letters at speeds upwards of 3000 an hour and the other segregates parcels from letters which are then separated into groups above and below 8in long.

A DEMONSTRATION of some of the prototype equipment which has been developed to hasten the sorting and handling of mail in this country was recently held at the head post office in Southampton. Two equipments of particular interest shown were an electronic sorting machine for letters and a letter and packet segregator. The letter sorting machine was developed some time ago at the Post Office research laboratories at Dollis Hill and has been undergoing trials in service at Southampton and other offices. It is illustrated in operation on this page. With this machine it is stated an operator can sort some 3000 letters an hour into the 120 destination boxes built within its framework.

As can be seen in the photograph, the operator sits at a keyboard at one end of the machine. This keyboard includes two groups of twelve keys and the machine can be arranged to sort either outwards mail—where the boxes are allocated to towns or districts—or for incoming mail which is sorted into boxes allocated to streets. Letters for sorting are fed face-forwards to the sorting point from a feed conveyor behind the keyboard. From this conveyor each letter in turn is picked up by a screw conveyor and carried forwards to a window at eye-level in front of the keyboard operator. This letter presentation equipment operates in response to the depression of two keys and in each sequence it feeds one letter into the main conveyor system of the machine, presents a second letter to the operator's window, and picks a third letter from the front of the unsorted stack. For sorting purposes a two-key code is arranged in accordance with the addresses on the letters. When the code keys for a letter have been depressed it is transferred by a main conveyor system into the selector roller conveyor system to be seen in the illustration. This selector system passes over rows of boxes and at appropriate boxes diverter blades come into effect to deposit the letters in accordance with the address code keys depressed by the operator.

The main conveyor system carries all letters from the presentation window to the start of a selective conveyor system, and it includes a synchronising gate which, if necessary, halts a letter for up to half a second in order to bring the letter into synchronism with the selective conveyor memory system. This necessarily means that letters enter the main conveyor at random time with respect to the memory system of the machine, and they have to be synchronised before entering the selective conveyor system.

This selective conveyor system consists of five horizontal conveyors situated over five rows of stacking boxes, and a vertical distributor which feeds the five horizontal conveyors. Diverter blades are interspersed along the conveyors to divert each letter to the correct horizontal run and thence to the correct stacking box. The diverters are operated at the appropriate time by linkages from pin wheel "memory units" which store the information keyed by the operator until the letter reaches the diversion point.

The drive for the letters on the main conveyor and on the selective conveyor system is provided by pairs of rollers comprising rubber-tyred idlers sprung against driven rollers. Every sixth idler is equipped with a centrifugal switch which stops the conveyor should a letter jam in the track.

The control for the machine is partly electronic and partly mechanical. This control system can conveniently be considered as four units: a cold-cathode code storage; a main pin-wheel memory; a thyratron translation field, and diverter pin-wheel memories.

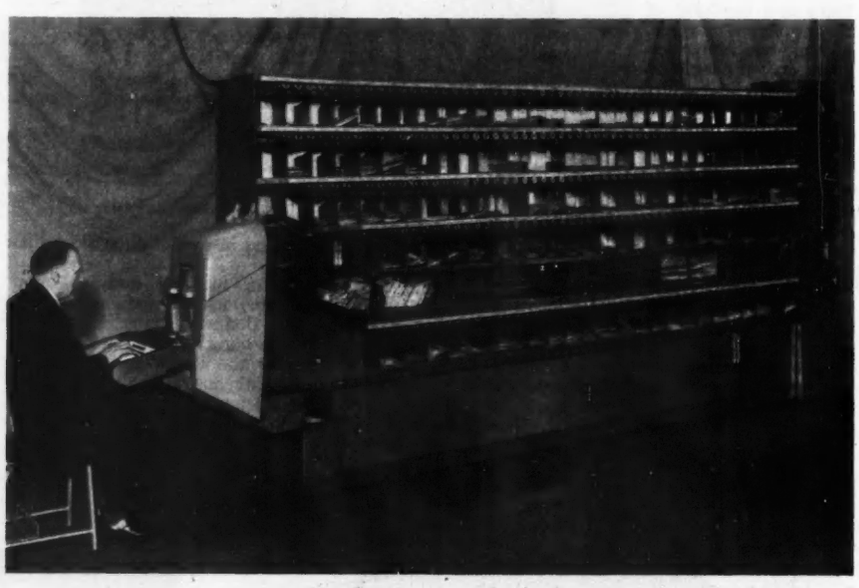
The cold-cathode store is provided to retain the information keyed by the operator until the main pin-wheel memory is in the correct position to permit setting of the pins. The storage time in the cold-cathode store can be up to half-a-second, which is the time interval between successive pins on the main pin-wheel memory. The information in the store is transferred to thyratrons which operate pin setting magnets upon being supplied (at the correct time for pin-setting) with an anode pulse provided by a switch operated by a cam driven in synchronism with the pin-wheel memory.

The main pin-wheel memory consists of twenty-four separate pin-wheels on a common shaft, each pin-wheel being associated with a particular key on the operator's keyboard. The main pin-wheel memory stores the keyed information in code form whilst the associated letter travels between the presentation unit and the synchronising gate. The letter is then held at the synchronising gate until the pins on the main pin memory which have been set for it operate "reading-off" switches. The letter is held at the synchronising gate for a maximum period of half a second, the waiting period at the gate for any particular letter being equal to the time that the coded information was held in the cold cathode store. In addition to controlling the synchronising gate, the "reading-off" switches also operate into a thyratron translation field which consists of a 12 by 12 matrix of thyratrons. Thyratrons with two grids are used and each thyratron has one grid in a column and one grid in a row. The left-hand part of the key combination acts on the grids in a row, and the right-hand part of the key combination acts on the grids in a column. By this means, for any given two-key combination, only the thyratron at the crossing point of the row and column associated with the two keys is fired. This performs the translation from code form to an individual selection.

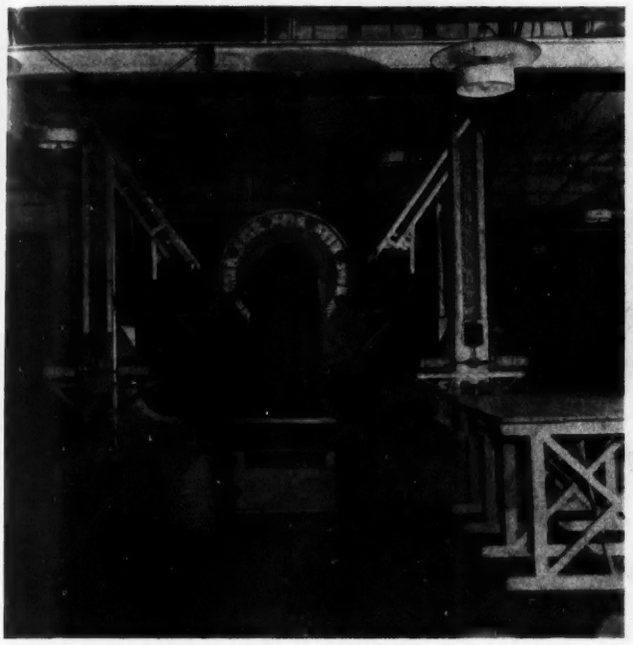
In the anode circuit of each thyratron is a pin-setting electromagnet associated with a stacking box diverter pin-wheel, and a pin-setting electromagnet associated with the appropriate "level diverter" (the diverter which routes the letter to the required horizontal conveyor) pin-wheel. Thus, a letter is released from the synchronising gate at the same time as a pin is set on the appropriate level diverter pin-wheel memory and on the stacking box pin-wheel memory. From this time the letter travels in synchronism with the pin-wheels so that as the letter approaches the level diverter and the box diverter they are operated mechanically by the pins which have been set to route the letter, first on to the correct horizontal level and then into the correct stacking box. The pin-wheels associated with the stacking boxes have too small a storage capacity to "mark" a letter from the synchronising gate to the most distant stacking box and it is necessary for the setting of pins on the more distant stacking box pin-wheels to be delayed until the letter has progressed some distance from the synchronising gate. In order to provide this delay, a second bank of "reading-off" switches is provided on the main pin-wheel memory which operates (about five seconds after the first set of reading-off switches) into a second 12 by 12 matrix of thyratrons. These thyratrons operate pin-setting magnets to set pins on the memory wheels associated with the more distant stacking boxes.

Although basically the control system is capable of sorting to 144 different selections, only 120 selections are used on this machine. It is provided with 133 stacking boxes, the surplus boxes being used to supplement the capacity of boxes associated with destinations for which there are heavy postings. A system of uni-selectors is used to control the distribution of letters between boxes associated with the same destination.

In addition to the twenty-four "code" keys on the operator's keyboard, a "feed" key and a "cancel" key are also provided. The feed key is thumb-operated and causes the presentation unit to perform one cycle of operation, feeding a letter into the conveyor system and routing it to a permanently open "overflow" box at the end of the top horizontal conveyor. This facility prevents the operator from being delayed by having to remove by hand any letter which he is unable to sort (e.g. incorrectly addressed letters or letters which arrive in the viewing window reversed or upside-down). The "cancel" key is provided to enable the operator to



Letter sorting machine. On the depression of two code keys by the operator letters are automatically delivered into any selected one of 120 boxes at a sorting rate of about 3000 per hour



Feed end of prototype machine developed for segregating parcels from letters, and separating letters above and below 8in long

Parcel exit end of segregator with "long" letter conveyors at the sides feeding transverse sorting benches

cancel his previous keying operation to divert a letter to a separate box should he realise that he has keyed incorrectly.

Two vertically disposed viewing windows are provided, a letter falling from the top window to the lower window at each keying operation. An experienced operator reads the address of the letter in the top viewing window whilst he keys the combination appropriate to the letter in the lower viewing window. By this arrangement, keying speeds can be increased by a substantial margin compared with a system where the operator is required to read an address and operate the appropriate keys for that address in one operational cycle.

A switch is provided on the machine to change the relationship between the key combinations and the position of the stacking boxes for the sorted mail, so that the machine may be used for sorting to delivery areas within the town (" inward sorting ") or for sorting mail to places outside the town delivery area (" outward sorting "). By this means it is possible to group the stacking boxes in the most convenient order for clearing, and at the same time to arrange for the boxes which have the heaviest postings to be associated with the most easily operated key combinations. Twenty machines based on this design are now being made for the Post Office by the Thrissell Engineering Company, Ltd., Bristol, for extended trials in service.

Letter and Packet Segregator

The prototype letter and packet segregator which is now undergoing extended trials in service at Southampton is shown in our second illustration. It is designed to separate thin letters from packages and bulky mail, and further to separate letters above and below 8in long. On this machine bags of mixed mail are emptied into the boot of a belt elevator at one end, and at the top the elevator drops the parcels and letters into an inclined rotating segregating drum.

The segregating drum is some 16ft long and it consists of a rigid framework of light alloy annular support rings coupled together by eight cylindrical spacing bars. The inner wall of the drum is built up of a series of counterbalanced hinged flaps which run the full length of the drum. These flaps overlap one another at their free sides to form lines of narrow slots through which thin letters can fall as the drum rotates. As each flap approaches the top of the drum it swings down slightly on its hinge to release any letters of intermediate thickness which might be trapped in the slot along its leading edge. Continued rotation of the drum brings the counterbalance means into effect to reduce each slot to the selection width upon approaching the mail distributed along and gravitating down the inclined drum. By the time the bulkier parcels and other mail reach a platform at the end of the drum all the thin letters have been removed.

Thin letters passing through the slots fall on to a belt conveyor below the drum and are carried back by this conveyor to the feed end, where they are deposited on to transverse conveyors. These transverse conveyors deliver the letters to " tower " units built on to each side of the main structure at the feed end. Each tower consists of a rigid frame across the width of which at 8in centres in the form of a ladder are pairs of driven rollers. Letters are picked up from the end of the transverse conveyor by the lowest pair of rollers in a tower and are fed upwards. Letters more than 8in long bridge the gaps between the sets of rollers as they are fed upwards and at the top of the tower are deposited into chutes leading down to sorting conveyor belts along each side of and immediately adjoining the selector drum. Short letters which cannot bridge the gaps between the rollers slip back on to inclined ejector fingers above each set of rollers. The letters gravitate down these fingers to a gap between the finger ends and the side panels of the tower. The letters falling down this side gap drop on to a second series of sorting conveyor belts parallel to, but spaced some distance from, the sides of the drum. On these sorting conveyors operators put the " short " and " long " into bundles with their faces the right way up for post-marking. It is planned to add at some future date a device which will receive the letters from the separate towers and automatically arrange them face upwards with the stamps in the same corner, ready for passage through the post-marking machine.

A simple machine which has been introduced recently at Southampton and has saved a considerable amount of time is a form of packet stamping machine. Very large numbers of journals and magazines are received in bulk from overseas at Southampton, where they have to be date-stamped. This work was hitherto all done by hand and entailed periods of peak working and overtime which have now been almost eliminated. The new machine simply consists of a short belt conveyor with two rotating dating stamps mounted on a centrally disposed bridge across its width. As the belt carries a package under a date stamp, it depresses a spring-loaded plate below the belt. This plate ensures that the correct pressure is applied to print the date stamp, and each time a plate is depressed it actuates the lever of a counter device at the side of the conveyor.

High-Temperature Laminating Resin

A low-pressure phenolic resin has now been evolved by Bakelite, Ltd., which will produce glass-fibre laminates for service at relatively high temperatures without serious loss of strength ; for short periods it may be used at 300 deg. Cent. The new material, V.17085, is a solution in industrial alcohol of a phenolic resin, and can be laminated at moulding pressures as low as 10 lb per square inch to produce high-strength laminates.

The standard curing time for glass fabric impregnated with V.17085 is one hour at 150 deg. Cent. Some variation of these conditions is permissible and the curing time may range from forty minutes at 160 deg. Cent. to four hours at 130 deg. Cent.

The properties of the laminate can be improved by a post-curing cycle, but this is not always necessary unless it is required to develop the heat-resistance properties of the laminate to the full.

A non-moisture-proof membrane on both surfaces of the laminate when moulding will help to absorb the water produced by condensation of the resin and will also act as a good release agent.

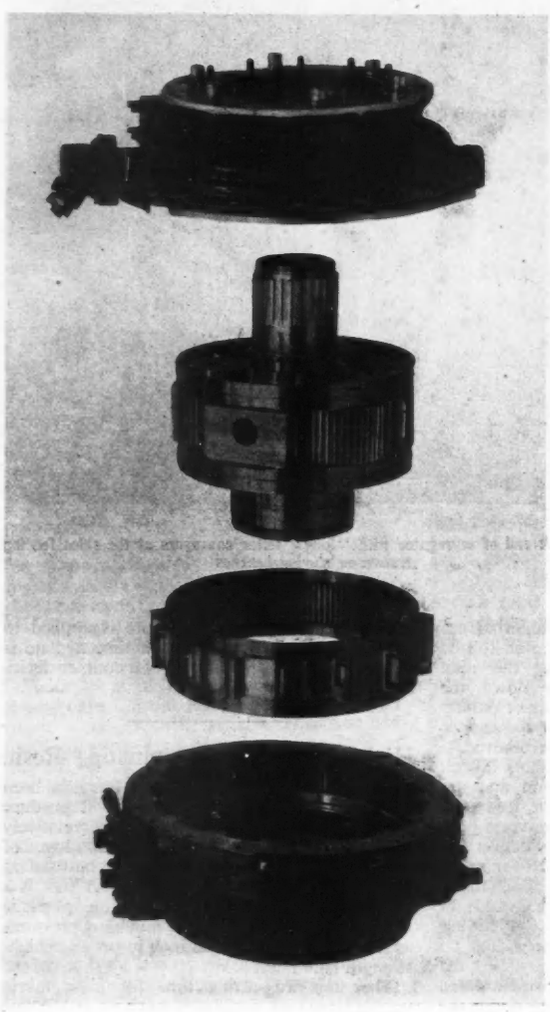
V.17085 can be used to make glass fabric laminates which have good heat resistance, and can be even further improved by blending in about 15 per cent of Bakelite liquid resin R.10993.

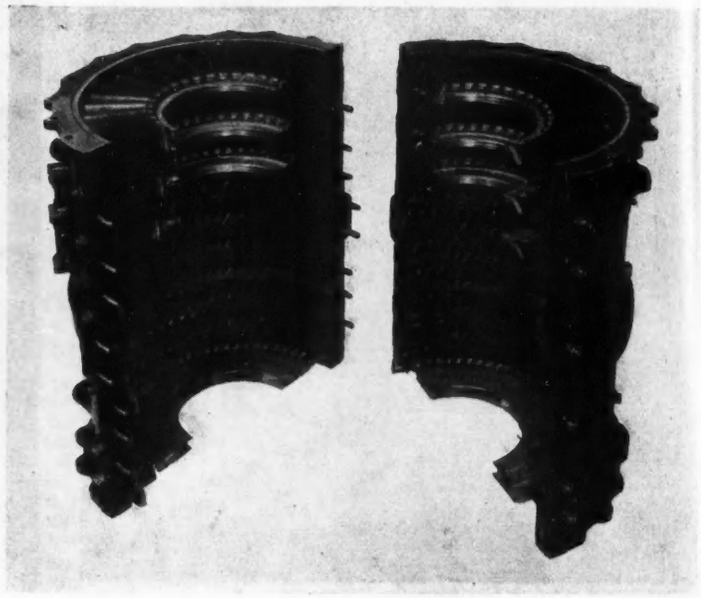
The glass fabric used is an important factor in achieving these results. At present the best fabric available in this country is an eight-shaft satin weave fabric which has been heat cleaned and "Volan"- or "Garan"-finished. In addition, better results can be obtained by post-curing the laminate. A suggested post-curing cycle is as follows :—

Six hours at 125 deg. Cent., increasing to 200 deg. Cent. in 25 deg. Cent. steps, with a six hours' dwell period at each stage ; cool slowly in oven to room temperature.

Flexural strength specimens tested at elevated temperatures in a Howden cross-breaking machine show that a mixture of V.17085 and R.10993 retains a high proportion of its strength —over 75 per cent—after 144 hours at 200 deg. Cent. or twenty-four hours at 250 deg. Cent.

Gas Turbine Design Details

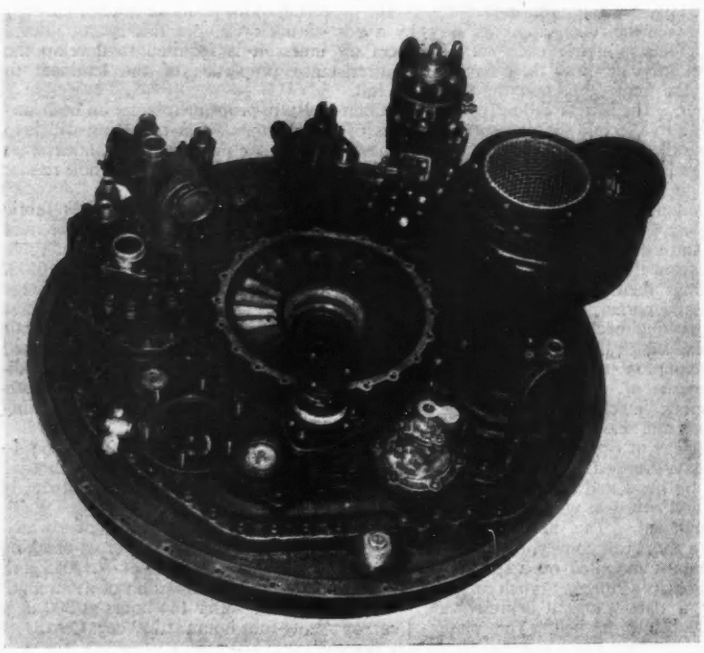




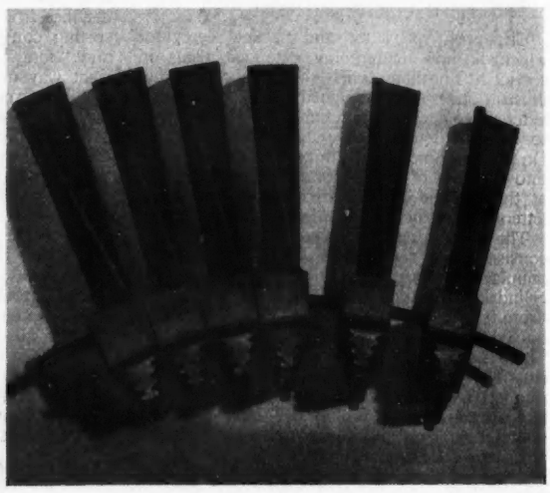
The Napier "Gazelle" shaft-power turbine for helicopters was described and illustrated on September 7 last, page 335. Some details of the design of this unusual vertical engine are seen here. At the bottom of the page and the engine is the annular air intake, below which is the accessory gear train, driving through shafts the auxiliaries on top of the cast magnesium intake. Conspicuous are the blower, delivering air to the oil cooler, and the dog for the starter drive. In the centre can be seen the trailing edges of the variable inlet guide vanes: the outer ends carry offset pins entering slots in a ring which is rotated to set the incidence. The vanes are hollow for hot-air de-icing.

The compressor casing is split longitudinally and carries the aluminium bronze blades in liners. The first three rows are shrouded, and the eleventh and last stage carries a transfer shroud which delivers air to a duct in the hollow shaft for delivery between the turbine discs for cooling purposes. The vanes within this annular duct prevent a vortex being set up opposing the inward flow. The rotor is built up of discs, aluminium for stages two to seven and the remainder stainless steel, the blades having fir-tree roots.

Cradled on top of the engine, between the bifurcated, bisected exhaust ducts, is the torquemeter. The reduction gear is a simple epicyclic with three planets: the ring gear floats in the casing and has fifteen outward-sprung vanes around its circumference. The housing has a corresponding set of vanes and oil is supplied to one side of each of the latter vanes and drained from the other. The pressure developed across the vanes on the ring gear opposes the torque, and indicates the output of the engine when the annulus is balanced. The torque signals are used to actuate safety devices in case of engine failure, such as overloading the remaining unit in a twin-engine machine. It can be seen in the picture, top left, that one of the vane housings is not milled away along the sides: this one acts as a travel stop for the ring. The accuracy of torque measurement is within ± 1 per cent. The output torque is not passed down to the engine, the magnesium gear casing being coupled to the airframe. Four links straddling the power turbine casing take the reaction of the third stage nozzles

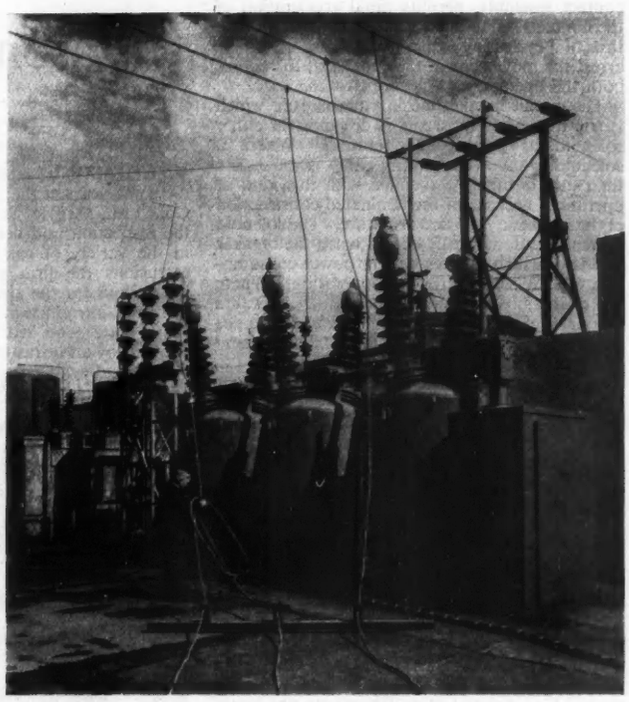


An unusual detail is the adoption of lacing to damp vibration of the blades. The blades are of "Nimonic," fitted in Austenitic discs by fir-tree roots, and have a certain amount of freedom even when first fitted. The extended platforms are pierced tangentially and a single lacing wire inserted before the turbine is assembled. The first stage power turbine blades have cooling fins on the front of the extended platforms, and they are inclined to draw cooling air out across them



132kV, 5000MVA Outdoor Oil Circuit Breaker

We illustrate a three-phase outdoor oil circuit breaker having a rupturing capacity of 5000MVA at 132kV, with a current rating of 1600A. It is an addition to The General Electric Company's "OD" range of circuit breakers, the increase in breaking capacity over the existing 2500MVA and 3500MVA equipments having been achieved solely by modifying the main contacts and arc control pots. In existing installations, therefore, the older "OD" circuit breakers can be uprated by completing comparatively simple alterations on site. The accompanying illustration shows the circuit breaker undergoing tests at the maker's works. The test results are tabulated below.



A NEW three-phase outdoor oil circuit breaker, type OFA.12, with a breaking capacity of 5000MVA at 132kV and a current rating of 1600A, has recently been introduced by The General Electric Company, Ltd., Magnet House Kingsway, London, W.C.2. It is an extension to the company's "OD" range and it is interesting in that the increase in breaking capacity, compared with the 2500MVA and 3500MVA units in this range has been effected simply by modification to the main contacts and the arc control pots. It is therefore possible for circuit breakers of the same basic design already installed to be uprated on site with minimum outage time by carrying out relatively simple alterations and replacements.

One of the new circuit breakers has recently undergone a comprehensive series of tests to prove its performance up to values in excess of 5000MVA. As a result of these tests, which were done in the company's high-power testing laboratory at Witton, an A.S.T.A. Certificate was issued confirming the rating. Details of the tests and the results obtained are tabulated here.

Tests on "OFA.12" Circuit Breaker 132kV, 1600A, 5000MVA Symmetrical

Test No.	No. of phases tested	Duty	Duty cycle	Fault current: Sym-metrical kA r.m.s.	Fault current: Asym-metrical kA r.m.s.	Equivalent 3-phase sym-metrical, MVA	Applied voltage, kV	Recovery voltage, kV	Equivalent percentage of rated system voltage (see note (1))	Arc duration in loops
1	3	10% break, symmetrical	B3-B3-B	1·94	—	440	—	110	83	4·4
2	1	30% break, symmetrical	B3-B3-B	7	—	1600	—	108	123	2·7
3	1	60% break, symmetrical	B3-B3-B	12	—	2700	—	53	121	2·6
4	1	80% break, symmetrical	B3-B3-B	16·5	—	3750	—	55	126	2·3
5	3	100% make	MB3-MB	—	63·7 Peak	5000	19	—	14	—
6	1	100% break, symmetrical	B3-B3-B	21·9	—	5000	—	46·4	106	2·5
7	1	100% break, asymmetrical	B3-B3-B	23	30·3	5200	—	47·5	108	2·3
8	1	115% break, asymmetrical	B3-B3-B	24·5	32·6	5600	—	36	82	2·3
9	3	5% break, symmetrical	B3-B3-B	1·08	—	250	—	116	88	4·4
10	1	50% make	MB3-MB	—	17·8 Peak	2500	78	—	102	—
11	1	40% make at double voltage	MB3-MB	—	14·7 Peak	2100	69	—	182	—
12	1	40% break at double voltage	B3-B3-B	9·1	—	2100	—	68·6	180	3·1
13	1	100% high-speed reclose	B— 0·38 sec —MB— 3 min —MB	19·5 — 20·5 — 20·9	20·7 53 peak 22 34 peak 20·9	4500 — 4700 — 4800	— 36·2 — 38·7 —	30·5 — 32 — 34·6	70 95 73 102 80	2·5 — 2·8 — 2·7
14	3-phase test on 1-phase	100% break, symmetrical (Biermann's)	B3-B3-B	22·9	—	5200	—	29 3-phase	67	1·9
15	3-phase test on 1-phase	100% break, asymmetrical (Biermann's)	B3-B3-B	22·2	28·5	5100	—	28·6 3-phase	66	2
16	1	Low current, low p.f. ...	6 breaks	0·019	—	—	—	75 (see note (2))	99	1·1
17	1	Transformer mag. current	6 breaks	0·061 peak	—	—	—	82 (see note (2))	108	1·7
18	1	Line switching	60 breaks	Various from 10 to 75A	—	—	76	(See note (3))	100	—

Test No.	No. of phases tested	Duty	Current at start: Peak kA	Current at start: kA, r.m.s.	Duration, seconds	Equivalent r.m.s. current, kA
19	1	Short-time current	48	25	3·03	21·8

NOTES ON TEST RESULTS

(1) The equivalent percentage of the rated system voltage is calculated, where appropriate, on the basis of a phase-factor of 1·3 for the first phase to clear. In the case of the switching tests at double voltage (tests Nos. 11 and 12), the phase-factor for this purpose is taken as unity.

(2) When clearing transformer magnetising currents and low currents at low power factor, no over-voltage greater than the normal restriking voltage transient for the test circuit was produced.

(3) No line-switching operation produced a greater voltage than 175kV peak on the line (over-voltage factor 1·6), and no more than one restrike was experienced on any operation. A restrike is here defined as current reappearing after an interval of a quarter-cycle or longer.

As can be seen from our illustration, the circuit breaker consists of three separate single-phase units linked externally to a common operating mechanism housed in a weatherproof cubicle. Each single-phase unit is enclosed in a cylindrical steel tank fitted with domed end plates welded in position. The condenser terminal bushings, which pass through the top dome in conical sockets permitting a small angular adjustment, are oil filled, ample air space being left inside the top of the assembly to allow for expansion and contraction of the oil. Ring current transformers are fitted; they are threaded over the condenser bushing within the current transformer chamber, which forms part of the oiltight and moisture-proof outer shell of the bushing. The secondary leads from the transformer are brought out to an external terminal box from which connections are taken, through conduit, to a terminal board in the operating cubicle.

There are two breaks per phase, the arcing contacts inside the arc control pots being designed to carry the full load current so that no external contacts are necessary. Each fixed contact assembly comprises six easily replaceable, self-aligning contact fingers, and an arcing contact. They are arranged to give circular line contact with the renewable copper contact tip fitted to the moving contact stem. The moving copper contact is tipped with arc-resisting G.E.C. "Heavy Alloy."

In common with all G.E.C. oil circuit breakers arc control is effected by side-blast pots. Equal voltage distribution between the two breaks in each phase is ensured by the provision of non-inductive switching resistors which are mounted adjacent to the arc control pots and are connected, during the arcing period, between the fixed and moving contacts.

The moving contacts are raised by a lifting rod of synthetic-resin-impregnated laminated wood, sliding, at its lower end, in guides of the same material. The upper end of the rod is connected, by a system of "Duralumin" levers in the top dome of the tank, to the horizontal pull rod which is actuated by the operating mechanism. The energy for opening the breaker is supplied by torsion bar springs fitted inside torsion tubes to form a compact unit. The low inertia of this form of spring, and of the moving

contact assembly, permits rapid acceleration of the contacts, enabling a total short circuit break time of 3 cycles to be obtained. Shock-absorbers arrest the movement of the contact at the end of both the opening and closing strokes.

The circuit breaker closing mechanism, which is trip-free in any position, is designed for either solenoid or pneumatic operation. Where a solenoid is used, the closing delay is much less than that normally associated with this kind of operation, because of the laminated construction of the magnetic yoke and armature. The solenoid current is automatically cut off when the breaker is closed, which reduces battery power consumption to 7kW-seconds for each operation. Where the circuit breakers are pneumatically operated the air engine is designed to work at 150 lb per square inch. Provision is made for manual closing and tripping during maintenance.

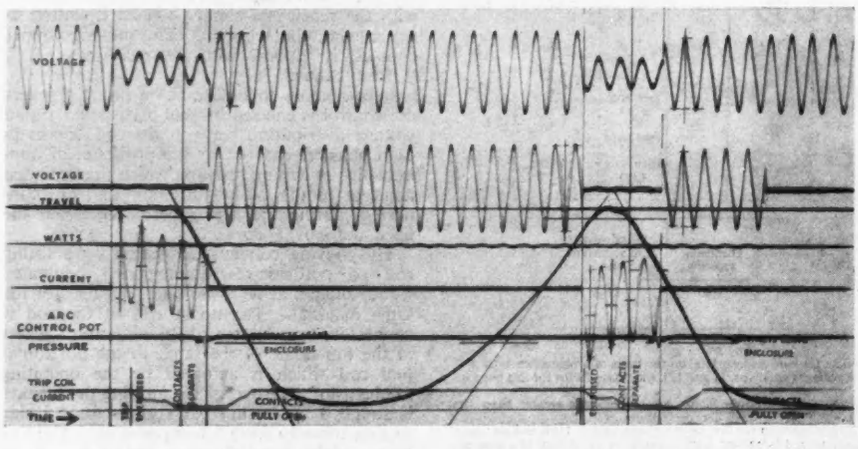
Three-phase, high-speed reclosing is an inherent property of the standard closing mechanism, since no resetting of the mechanism is necessary before starting the first reclosing operation. The circuit breaker can also be equipped for single-phase reclosing by a rearrangement of the standard mechanism. In this case, as in the standard equipment, all three phases are closed by a common solenoid or air engine, thus ensuring simultaneous closing of all phases when three-phase closing is required. Three-phase tripping is similarly synchronised by means of a common trip coil when this arrangement is used.

Tests

The results of the tests carried out at the Witton high-power testing laboratory are given in the table on page 691. Tests 1 to 8 and test No. 19 were carried out in accordance with the requirements of B.S. 116 : 1952 and of A.S.T.A. No. 15 published by the Association of Short-Circuit Testing Authorities. The remaining tests are supplementary to the requirements of existing specifications, but were considered necessary for the complete proof of the circuit breaker for all service conditions such as high-speed reclosing (test 13), switching two systems which are out of synchronism (tests 11 and 12) breaking small highly inductive currents (tests 16 and 17), and switching unloaded transmission line (test 18). The fact that the G.E.C. high-power test plant is connected to a considerable section of the 132kV grid enabled the line switching tests to be realistic.

In all the breaking tests, the moment of contact separation was controlled in relation to the current wave and was adjusted for each operation to ensure that tests were made to cover all conditions likely to be met in service.

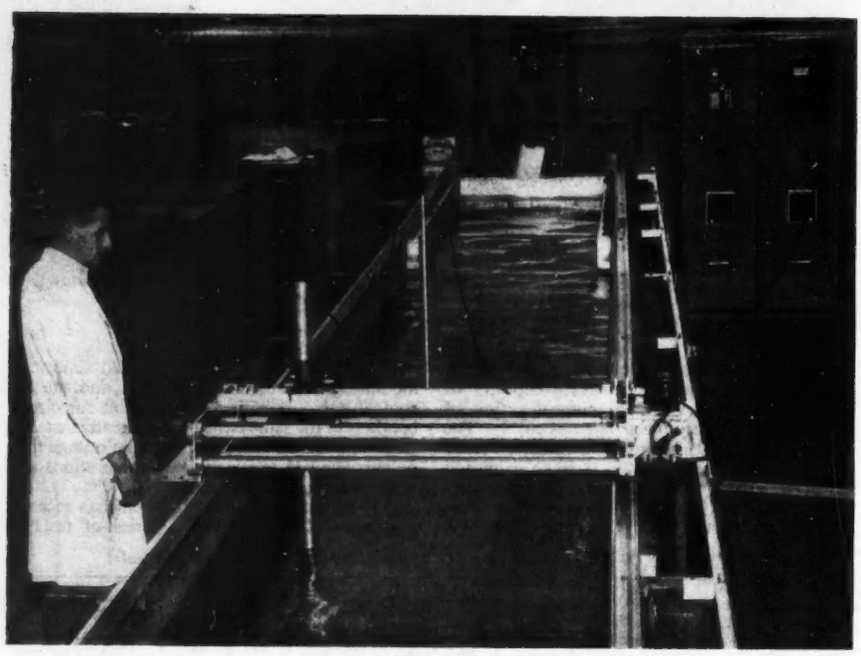
Tests were carried out with both solenoid-operated and pneumatically operated circuit breakers. The high-speed reclosing times published in the table (test No. 13) are obtainable with a standard solenoid-closed breaker, but should a shorter reclosing time be required it can be provided by a closing coil of increased power or by the standard pneumatic closing mechanism. An oscillogram of the high-speed reclosing portion of test No. 13 is reproduced below.



Oscillogram of high-speed reclosing test on 132kV, 5000MVA oil circuit breaker

Ultrasonic Flaw Detection Equipment for Large Plates

ULTRASONIC equipment has been used for some years at the works of James Booth and Co., Ltd., Argyle Street, Birmingham, 7, for the inspection and detection of flaws or defects in the variety of castings, forgings, plates and extrusions the firm produces in high-strength light alloys for the aircraft and other industries. A recent introduction is an equipment by which large plates and extrusions are automatically scanned by an ultrasonic probe which is coupled electronically to an indicating and recording equipment which provides a continuous and permanent record of any flaws or defects in the material.



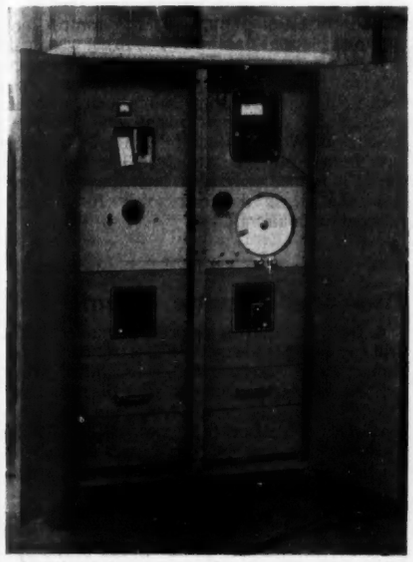
Water-filled tank, in which plates and extruded sections are tested ultrasonically for flaws and defects by means of a motorised probe carriage mounted on a bridge which runs along the tracks on the tank

This equipment, which has been built by the firm, is shown in the accompanying illustrations. In it testing is carried out using the immersion principle in which the plate is submerged in a tank of liquid by which acoustic coupling to the probe is maintained. The tank is some 40ft long by 4ft wide and is fitted with tracks down the full length on either side. A bridge spans the tank and on it there is mounted a carriage with an ultrasonic probe fitted with a ½in diameter crystal. The bridge is traversed along the track at speeds up to 60ft per minute by an electric motor drive. The probe carriage is traversed across the bridge through a lead screw and gearing turned by an electric motor. At the end of each longitudinal traverse of the bridge along the length of an immersed plate the carriage motor turns the lead screw a sufficient amount to move the probe carriage ½in along the bridge, so that the probe traverses the whole area of the plate in overlapping increments.

The probe is coupled to a modified Solus-Schall ultrasonic flaw detector, on the screen of which any flaws are shown as smaller peaks between the trace peaks of the upper and lower surfaces of the plate undergoing inspection. This instrument is preset before an inspection pass over a plate by means of standard test pieces or targets in which there are drilled flat-bottomed holes of predetermined sizes. Two modified Solus-Schall monitors are coupled to the detector, one of which can be set to give warning if the intensity of the top surface reflection falls below a predetermined level, and the other to indicate defect signals above a certain magnitude.

The recording equipment, to be seen in our second illustration, incorporates a rotating disc which is synchronised with the longitudinal movement of the probe bridge along the tank, so that it makes one rotation for each complete traverse. Two limit switches are fitted on the disc and they can be set to reverse automatically the direction of bridge travel. By setting these switches by means of two knobs below the disc the probe can be traversed over the whole or only a part of the length of the plate in the tank. At each switch reversal the bridge motor is energised to move the probe carriage ½in along the bridge so that the whole area of the plate is progressively scanned.

A sheet of "Teledeltos" electrosensitive paper fixed on the rotating disc is used to record flaws in the material undergoing inspection. A stylus in front of this recording paper moves radially



Control cabinet housing a standard ultrasonic test unit coupled to the probe, and two standard monitors. On the right is the combined controller-recorder

over the disc in relation to the transverse movement of the probe. Whenever the defect registering monitor receives a flaw signal above a preset magnitude an electric charge is transmitted to the stylus and the resulting spark produces a charred dot on the "Teledeltos" paper. The pattern of charred dots so formed shows the pattern of any flaws in the plate being scanned. If it is required to assess the actual magnitude of any defect the probe carriage can be manipulated by push-button controls over the positions indicated in the first scanning operation, and the peak pulsations compared with those from the flat-ended holes in standard target pieces.

The Kelvin Hughes high-speed strip-recording equipment on the left-hand side of the control cabinet is used for resolving large diffuse defects of low reflecting power in plates. With this form of recorder there can be obtained on a roll of "Teledeltos" paper a magnified trace of the profile of the defect signal as the probe is traversed over the material.

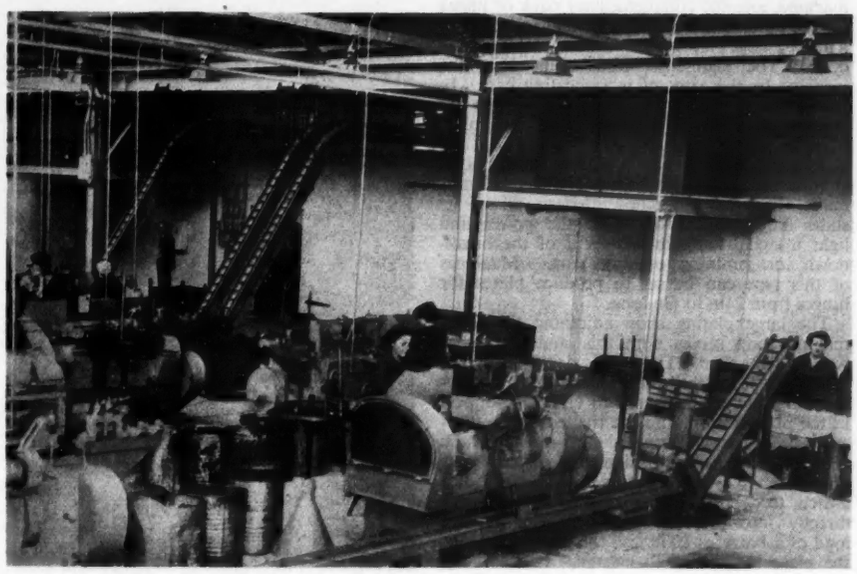
We are informed that this equipment has been giving satisfactory service in the firm's production shop for some time. Under further development work now in progress a number of improvements will be introduced; the question of using a 4½in crystal probe is also being considered, with a view to increasing the operating speed of the equipment.

INSTITUTION OF NAVAL ARCHITECTS.—The summer meeting of the Institution of Naval Architects will be held in Bristol from July 9 to 11, when the following papers will be read:—On Tuesday morning, July 9, "Merchant Ship Design, Some Æsthetic Considerations," by Laurence Dunn, and "Tug Power in Relation to the Towage of Swim-Ended Barges," by J. B. Griffith; on Wednesday morning, July 10, "Design of Wooden Naval Vessels," by K. G. Evans; "The Prediction of Smooth Ship Resistance from Model Data," by G. Hughes, D.Sc.; and "Ship Stabilisation—Controls and Computation," by J. Bell, M.Sc. During the meeting visits are to be paid to the Bristol Aeroplane Company, Ltd.; the University Engineering Laboratories; W. D. and H. O. Wills Tobacco Company, Ltd.; the Avonmouth Docks; and J. S. Fry and Sons, Ltd.

SEMI-TRAILER SHUNTING.—To manœuvre a variety of semi-trailers into and out of depots, a Douglas "Tugmaster" has recently been shipped to Compagnia Shell de Venezuela. The lower half of a 33in S.A.E. fifth wheel is mounted at the trailing end of a hinged frame, which can be raised or lowered by a pair of hydraulic rams controlled from the cab. Side loads are taken by guides projecting down beyond the chassis and in contact with the plates on which the cross member carrying the rams is slung. There is very little ground clearance and the rear axle is fixed directly to the chassis. An 18in range of adjustment is provided for the turntable. The coupling pin is controlled from the cab: since a suitable turntable setting allows a trailer to be moved with the undercarriage extended, the driver does not need to leave the cab. Trailers up to 60 tons can be handled, and the maximum speed is 15 m.p.h.

Hinge Making Factory

A NEW factory specially designed and equipped for the manufacture of hinges has been opened by Thomas Crompton and Sons, Ltd., at Haydock, in Lancashire. This firm, one of the largest of its kind in the country, has been connected with the manufacture of hinges for some 200 years, and the new factory will enable an appreciable increase in the output of hinges, locks, handles, and equipment made at its other works. The new factory covers an area of about 44,000 square feet, and in its construction provision has been made for easy extension of the production floors at any future date.



Hinge assembly machines, with conveyor to packing station and elevators to adjoining plating shop

The main production area of the factory is broadly arranged in three sections concerned with the manufacture of light and medium hinges, heavy hinges, and brass and kitchen cabinet hinges. The general flow of production in these sections is across the width of the floor in machine lines, each line starting with a press to which coiled strip is supplied by fork truck from a stores section at one end of the building. With the exception of the presses a fairly large number of the machines are hand fed, but an increasing amount of plant is being introduced for carrying out multiple operations automatically.

The section making light and medium hinges of standard and non-standard patterns includes seven complete and two half-lines of machines. At the start of each line the plates for each half of a hinge are cropped and pierced in pairs on presses. On successive or multi-operation machines each hinge plate has the two tags for its hinge pin bearings first rolled and these bearing ends are then milled to give the required interlocking gaps. The holes are countersunk and the plates are then barrelled with sawdust to clean off all oil and swarf before transfer to a hinge assembling machine. Here the operator puts the two plates together before they are automatically clamped with the pin bearings in line for the insertion of hinge pins, which are either stored in a magazine or cropped as required on different machines. One of these assembly machines can be seen in the foreground of one of our illustrations. From this machine the completed hinges drop on to a conveyor belt at the rear for transfer to a packing station at the end of the line.

Multi-operation automatic hinge plate forming and countersinking machine

Three of the lines in this section produce hinges which are afterwards electro brass plated, and the inclined conveyor system seen in the background of our illustration is used for transferring these hinges to the adjoining plating department.

Amongst the automatic special-purpose machines in the heavy hinge section is the multi-operation machine in the second illustration. The two plates for each hinge are cropped in pairs on the press at the head of this line and are ejected threaded on bars to form packs ready for loading on the multi-purpose machine. The packs of plates for one half of the hinges are loaded into a magazine on one side of the machine, and the complementary pack of plates for the other half into the other magazine. Thus a pair of hinge plates is produced in each machine cycle. The plates are transferred along the machine by the arms of reciprocating bars. In the passage through the machine each plate has the projecting tags for its pin bearings rolled in three operations, the gap sides milled by a rotating broach, and the three screw holes countersunk. The machine is completely automatic, and microswitches fitted to all of its slides are arranged to cut off the power and light a signal lamp in the event of the breakdown or jamming of any part. Machines of this type can be set to produce plates for hinges from 2½in to 6in long.

The large plating shop adjoining the hinge making shop serves both this and the other works of the firm. The hinges delivered by the conveyors from the three light automatic production plant are delivered to elevated hoppers in the plating shop, and are treated in a twelve-stage brass barrel plating plant. An automatic transfer and batching equipment fed from these hoppers enables an operator, by depression of a switch, to deposit the correct quantity of hinges directly into a plating barrel. The average load of a barrel is 80 lb and the twelve stages of the plant include alkali cleaning, two swilling, five plating, two cold swilling, one hot swilling, and drying stages. The other equipment in this shop includes plant for the barrel and still plating of copper, zinc and nickel; automatic brass plating; and nickel and chrome still vat plating.

Defensive Missiles

PARTICULARS of three anti-aircraft missiles have recently been revealed: the surface-to-air Bristol "Bloodhound" which is in production; an English Electric surface-to-air weapon which has been ordered; and the "Firestreak" which has been ordered from de Havilland Propellers, Ltd., for the Royal Air Force.

The "Bloodhound," powered by Bristol "Thor" ramjet engines, is the result of collaboration between Bristol and Ferranti since 1949, and there are now, respectively, four and two factories engaged on various forms of weapon production. Bristol Aircraft, Ltd., has borne the overall responsibility for the weapons system. The guidance system has not been clearly described, except that detection is by radar; however, the ramjet is essentially a long-range interception weapon, whereas weapon homing systems are usually limited in power, so it may be expected that the missile will be radio-controlled in flight; this will be relatively easier with a ramjet than with a vehicle followed by a highly-ionised rocket exhaust. The final stages of the interception may take the form of active or semi-active homing. The warhead is unspecified, but since the system is capable of despatching two missiles against two aircraft in close formation, is presumably not fissile. It is claimed that the complete weapons system can be used within the existing defensive organisations of many countries. No photographs are available of early missiles under test, since the form of the weapons has changed little during development. A "Bobbin" with "Thor" engines was illustrated on page 497, of our issue of March 29, 1957.

Fig. 1—An English Electric test vehicle immediately after separation of the four boosters clustered round it: the boosters each have a fin and an assymmetrical nose cone to give a separating force

Fig. 2—A "Firestreak" accelerating away from its parent aircraft

The English Electric guided weapons system, a test vehicle for which is seen in the adjacent illustration, is claimed to utilise a minimum of ground equipment, comprising assembly and test facilities and remotely controlled launchers, and therefore may be inferred to be an active homing missile. Photographs show that the sustainer remains in action until a late stage in the flight, so that it appears that it must utilise the long burning time charges that have been a feature of the work at R.A.E., Westcott, but there is an alternative liquid propellant rocket motor. It is to be produced by the various factories of the English Electric Company, Ltd.

In production for use by the Gloster "Javelin" and English Electric "P.1" aircraft, the "Firestreak" employs infra-red passive homing. Since the attenuation of infra-red in clouds and rain is severe, this suggests that it will be used by the all-weather fighters for engaging aircraft flying above themselves. This makes a propelled rather than a coasting weapon desirable, and the illustration shows that a sustainer able to accelerate the missile into controlled flight without the use of boosters is employed. A turbo-alternator is carried, so that it may be expected that the oxidant is hydrogen peroxide, known to be favoured for Service use because of the logistic difficulties associated with liquid oxygen. It is, apparently, not compatible with the present aircraft interception equipment, since de Havilland Propellers, Ltd., has also developed ancillaries for the carrier.

A remarkable fact about the "Firestreak" is that it has been fired ground-to-ground; this was the first test of the guidance control loop and took place at Larkhill. The firing was made at night; infra-red systems are, of course, prone to seek the sun. Subsequently, missiles have been fired from "Venom" aircraft at sub-sonic speeds, and also from swept-wing "Sabre" fighters at Woomera, and "Jindivik" targets have been destroyed in flight. The illustration shows it immediately after launching, and suggests that it is designed solely for carriage external to an aircraft.

Two-Speed Portable Electric Drill

A GENERAL duty two-speed portable electric drill now being made by Wolf Electric Tools, Ltd., Hanger Lane, London, W.5, is illustrated below. It has a drilling capacity in steel of ¼in at high speed (1200 r.p.m. on full load) and ½in at low speed (450 r.p.m. on full load). When drilling hardwood the machine has higher capacities—1in diameter at low speed and ⅝in diameter at high speed.

A selector mechanism is incorporated in the gearbox of the machine and the transmission gears are in constant mesh. Speed selection is effected by the engagement of clutches integral with the final spindle gear wheels, and is obtained by a push/pull plunger on the outside of the gearbox. The machine can be supplied with either a ½in drill chuck or a No. 1 Morse taper socket. Models are available with universal motors for d.c. and single-phase a.c., 25/60 cycles, and for various voltages from 100/110V to 220/250V.

Two-speed portable electric drill in use. Holes up to ¼in can be drilled at high speed, and up to ½in at low speed, in steel

The makers point out that a particular advantage of this tool is that when drilling deep ½in diameter holes, high penetration speeds can be obtained by first drilling a ¼in diameter pilot hole and then opening out the hole with a ½in drill at the lower speed.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—A paper entitled "Diagnosis and Analysis of Plain Bearing Failures," was read by P. P. Lover, B.Sc., Wh.Sc., at a meeting of the Institution of Engineers and Shipbuilders in Scotland, held on April 16. The four causes of failure of a bearing are stated to be faulty design, faulty manufacture, faulty assembly, and faulty use, and each of these aspects is considered in turn, although they cannot always be entirely separated. A number of bearing failures are illustrated and references are included to some sources of design information.

Industrial and Labour Notes

Industrial Disputes

The Ministry of Labour has stated that in 259 stoppages of work through industrial disputes in the United Kingdom, there were 3,646,000 working days lost during March by 600,800 people. This exceptionally high figure of time lost was, of course, brought about mainly by the strikes in the shipbuilding and engineering industries.

In the shipbuilding industry, the stoppage of work continued from March 18 until April 3, and involved about 155,000 people, with an aggregate loss during March of 1,518,000 working days. In the engineering industries, there were strikes in different areas from March 25 until April 3. The number of people concerned in them was approximately 401,000 and the time lost aggregated 2,011,000 working days.

The Ministry says that in the first three months of this year there were 696 stoppages of work through disputes. In them, 669,000 workpeople were involved and the number of working days lost totalled 3,877,000. In the comparable period of last year, there were 717 stoppages which involved about 170,800 people and caused an aggregate loss of 657,000 working days.

Comment on Strikes

The annual meeting of the Amalgamated Engineering Union's national committee began on Monday, at Eastbourne. It opened with an address by the president, Mr. W. J. Carron, in which he said that strike action was the most potent and drastic weapon in the trade union armoury. If its sharpness and brightness were to be preserved, the unions should not become prone to the indiscriminate use of that weapon for "any odd job" that presented itself. The worker, Mr. Carron added, wanted strikes even less than the employer; while the employer might be able to recoup his loss by business methods, the worker suffered permanent financial loss. About the recent disputes in the shipbuilding and engineering industries, Mr. Carron's main comment was that the economy of this country was placed in most serious jeopardy by the irresponsible actions of the most powerful body of organised employers in Britain.

Some observations on strikes have also been made this week by Mr. Halford Reddish, chairman of the Rugby Portland Cement Company, Ltd., in a statement circulated with that company's annual report. Mr. Reddish comments that strikes in these days are a costly and entirely unnecessary anachronism which Great Britain cannot afford. But, he asks, what is meant by a "strike"? If, Mr. Reddish continues, a man gives notice to leave his employment in accordance with the terms of his contract of service, all well and good. It is the right of any man to choose and change his employment in a constitutional manner, and, the statement goes on, it is still legal for men "to combine in restraint of trade to do just this." But, Mr. Reddish then says, if a man withdraws his labour without such notice, in flagrant breach of his contract, he is guilty of gross misconduct and should be dismissed. Whether he is re-engaged by the same employer at a later date is a matter for the employer. But, Mr. Reddish emphasises, without sanctity of contract, without the honouring of obligations freely entered into by both parties to the contract, the whole fabric of civilised society must eventually fall apart and something akin to anarchy prevail.

These reflections, Mr. Reddish adds, are prompted by recent events in the shipbuilding and engineering industries, which had a disastrous, if exaggerated, impact on opinion abroad. It is common knowledge, Mr. Reddish asserts, that a majority of the men did not want to cease work, yet they can apparently be persuaded to do so by "subversive elements exercising an influence out of all proportion to their numbers." For that state of affairs, the statement says, both the leaders of individual businesses and responsible trade union leaders must share the blame. A man's first loyalty, Mr. Reddish declares, should be to the company in which he works, the company to which he is selling his labour.

Overseas Trade

The Board of Trade has issued its detailed survey of Britain's overseas trade in March and in the first quarter of this year. The value of exports in March was £297 million, and the value of imports rose to £362 million. Re-exports were valued at £16,500,000, the highest figure recorded in any month since March, 1952. The visible trade deficit was thus £48,500,000 in March, or much about the same as the monthly average for 1956.

During the first quarter of the year, the monthly average value of United Kingdom exports was nearly £279 million. This was almost the same as for the last quarter of 1956 and 8 per cent above the average for the first quarter of last year. After allowing for silver bullion repayments to the U.S.A., the increase in value over a year ago was 7 per cent. The Board of Trade says that export prices have continued to rise this year—probably a little faster than last year's rate of 4 per cent—and the volume of shipments in the first quarter was 3 to 4 per cent higher than a year ago, compared with a volume increase of 6 per cent during the year 1956. As to the "commodity pattern" of exports in the first quarter of this year, the Board's survey shows that engineering exports averaged £109 million a month, an increase of £5,000,000 over the comparable period last year. The rate of expansion of engineering exports has fallen off since the middle of last year, mainly as a result of the decline in exports of road vehicles and aircraft. At a value of £30,000,000 a month, exports of these products were 5 per cent higher during the first quarter of this year than in the latter half of 1956, but they were still 8 per cent lower than in the first quarter of 1956. The subject of last year's motor vehicle exports is dealt with in the following note.

Exports of the Motor Industry

An analysis of the destinations of exports of the products of the motor industry during 1956 shows that, although the British Commonwealth and Empire, with Eire and Sudan, continued to take the bulk of the goods, the U.S.A. became the largest customer for cars, buying £16·2 against Australia's £14·9 (all figures in millions sterling), although Australia received a 50 per cent larger number of cars. Car exports totalled £113·4 (£122·5 in 1955), with the Commonwealth taking £63·2 (£80); besides the U.S.A., the principal foreign buyers were Austria £1·1 (£0·7), Belgium £5·3 (£4·4), Denmark £2·8 (£2·2), France £1·7 (£1·6), W. Germany £1·6 (£1·8), Ireland £2·4 (£5·7), Netherlands £3·2 (£3·8), Sweden £5·8 (£6·1), and Switzerland £1·3 (£1·2).

The trade in commercial vehicles, parts and accessories, industrial vehicles, trailers, and engines increased, with the demand of the Commonwealth again dominating the trend. Commercial vehicles totalled £93·7 (£87·1), with the Commonwealth absorbing £59 (£55); major customers, apart from the countries which also bought cars, were Finland £3·5, Norway £1·0, Portugal £2·2, and Spain £2·3. Exports of parts and accessories increased £15 to £121, India rising £4, while agricultural tractors dropped £5 to £44, the Union of South Africa, Australia, Ireland and Sweden being largely concerned.

During the first three months of this year car exports, numbering 90,677, were similar to last year's figures, while goods vehicles were less at 27,613 and public service vehicles substantially greater—1503 against 964. Production during the quarter was markedly less than in the two previous years, and this was particularly true of January.

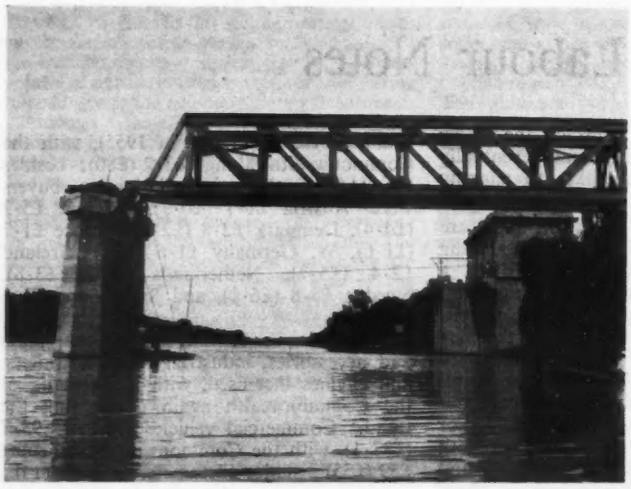
Birmingham Engineering Centre

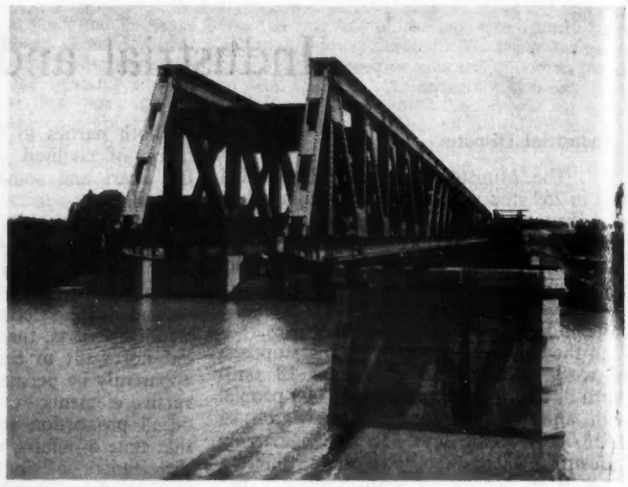
At the annual general meeting of the Birmingham Exchange and Engineering Centre, on April 11, the president, Mr. Victor Brenner, stated that the centre was maintaining a live and virile organisation with a special interest in export markets. He said that there were now 273 permanent exhibitors at the centre, compared with 207 when it was opened three years ago. Mr. Brenner added that the number of visitors remained fairly constant at about 5000 a month. That figure, he remarked, might not appear high when compared with attendances at exhibitions of limited duration, but the exhibition at the centre was permanent, and most of those who visited it did so for a definite purpose, usually to make a specific inquiry.

Steelmaking Scrap

In its report for 1956 (see page 667 of this issue), the British Iron and Steel Federation has something to say about the special efforts made last year to conserve scrap supplies by raising the proportion of pig iron used in steelmaking. The saving in scrap consumption, the report says, was significant. Towards the end of the year, the cost of imported scrap rose to record levels and, as supplies of steelmaking pig iron increased, the possibility of using a still greater proportion of pig iron in steel furnace charges was considered.

During last year, a special effort was made to encourage the recovery of old tins from domestic and trade refuse by local authorities, and 11,000 more tons of this kind of scrap was obtained than in 1955. Imports of steelmaking scrap last year totalled 961,000 tons—263,000 tons less than in 1955—the main source of supply being the U.S.A. Freight rates continued to rise, the report adds, and the price of imported scrap exceeded previous limits.





Two stages in the launching of the new railway bridge over the Vaal River

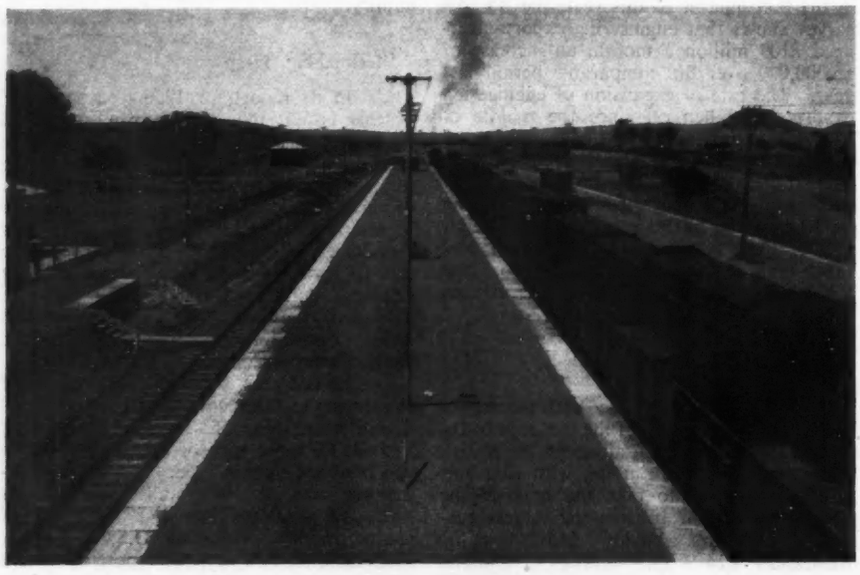
Doubling and Electrification of South African Main Lines

BY OUR SOUTH AFRICAN CORRESPONDENT

WITH the completion of the Orange Free State main line between Bloemfontein and Vereeniging in November last, two of the Union's capitals, Pretoria, the administrative capital, and Bloemfontein, the judicial capital, will be connected by a double railway line, a distance of 288 miles. Actually, there will be a double line from the Eastern Transvaal coalfields and the Witwatersrand gold mining area through the Orange Free State as far as Bloemfontein, a distance of 334 miles. The work on the O.F.S. line is part of a £12,000,000 improvement scheme, which included the building of fourteen road bridges or subways to eliminate dangerous level crossings. In conjunction with the doubling of the line a number of deviations were carried out to improve alignment and grading and, as a result, eight stations had to be completely rebuilt on new sites. Of these, the illustration below shows the construction at Brandfort as a typical example.

Track remodelling and additions were necessary at every station between Vereeniging and Van Tonder. New station buildings have been provided at six stations and at the other stations the signal cabins have had to be replaced or enlarged. In two cases, double-storied signal cabins have been provided. The doubling of the line has also necessitated the doubling of ten river bridges, and a further ten new river bridges have had to be built, the largest being that over the Vaal River near Vereeniging. We reproduce views of this bridge in the process of launching. It consists of three centre spans, each 150ft long with 30ft concrete flanking arches on each side. The next largest is the Vetrivier Bridge, which consists of seven 80ft spans 80ft above the river bed. Incidentally, the second longest double line in the Union is at present being built between Durban and Ladysmith, a distance of 110 miles. An amount of £21,000,000 will have been spent on doubling tracks all over the Union when the programme is completed.

In addition to the doubling of these lines, it is interesting to note also that two sections in the Eastern Transvaal to Kroonstad in the Orange Free State, distances of 222 miles and 206 miles, are being electrified at a total cost of nearly £6,000,000, and when the project is completed, Pretoria and Kroonstad, a distance of 162 miles, will also be connected with an electrified line. Work is well under way on some of the sections, and when the electrification gang crosses the bridge over the Vaal River the first electrified line on the Orange Free State system will be started. The other three provinces have had electrified sections for many years, Natal since 1921, the Cape since 1928, and the Transvaal since 1936. As a result of these improvements, the carrying capacity of the line between Bloemfontein and Vereeniging will be increased from about 25,000 tons a day to more than 45,000 tons a day. Passenger trains will, for the present, not be affected, although the line has been shortened by 4½ miles, but goods trains are moving much faster over this section. A goods train which used to complete the journey between Bloemfontein and Kroonstad in sixteen and a half hours now takes only eight and a quarter hours. The running times between Kroonstad and Vereeniging have also been reduced. It is expected that running times of goods trains over these sections will eventually be cut by about twelve hours.



New station at Brandfort

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

CLASS I OXY-ACETYLENE WELDING OF STEEL PIPELINES AND PIPE ASSEMBLIES FOR CARRYING FLUIDS

No. 1821 : 1957. Price 10s. This revised standard takes account of the proposals contained in B.S. 2633, "Class I Metal Arc Welding of Steel Pipelines and Pipe Assemblies for Carrying Fluids." The revision specifies requirements for the shop and site oxy-acetylene welding of steel pipelines and pipe assemblies for carrying fluids, the products being suitable for Class I conditions and available in sizes up to 24in diameter. It deals with all types of butt welds and branch and sleeve welds.

Qualifying tests for welders are dealt with in three sections: "Procedure Qualifications Tests"; "Qualification Tests for Welders"; and "Testing of Specimen Welds for Procedure and Welder Qualifications." Appendices contain recommendations on welding techniques, methods of preparation for macro-etching, and non-destructive examination of pipe joints.

TYRES : RAILWAY ROLLING STOCK MATERIAL

No. 24, Part 2 : 1956. Price 3s. 6d. This revised standard dispenses with the previous practice of allotting "specification numbers" to individual products, as it is considered that products can be adequately identified by describing them and by quoting the number, part and section of the standard.

The first section of the specification deals with locomotive tyres (previously known as Specification 4, B.S. 24, Part 2), and the second section with carriage and wagon tyres (previously known as Specification 5 and 5A, B.S. 24, Part 2).

Each section includes requirements for quality of material, methods of selection for test and methods of test. An appendix gives details of the form of tensile test piece, together with an illustration. Requirements for a new class of tyre which will stand up to heavy braking on severe gradients and rough roads are included in both sections of the standard.

German Industries Fair, Hanover

No. 1

THE German Industries Fair, which opened at Hanover on Sunday, April 28, and which closes on Tuesday, May 7, again combines the light and heavy sections, but no large machine tools are to be seen as they will be displayed at the fifth European Machine Tool Exhibition at Hanover to be held from September 15 to 24. The following table shows clearly the growth of this annual Fair :—

Year	Halls, square metres	Open area, square metres
1947	30,000	8,000
1950	75,000	30,000
1955	220,000	75,000
1956	230,000	120,000
1957	240,000	140,000

This year there has been further construction of permanent exhibition accommodation by the leading iron and steel firms. In our last year's article, we referred to the new Demag building, and this year we show in Fig. 1 the new building completed by Fried Krupp. It more than doubles the original space in the dome shown to the left. The total area is now well over 1000 square metres, in addition to new office space, and a reception hall in which films can be shown. Other buildings completed this year include those of the Siegener A.G. of Geisweid, and the August Thyssen-Hütte to which some reference will be made in later articles.

On Saturday evening, April 27, an informal dinner was held in the main restaurant, at which the Deutsche Messe und Austellungs Ag welcomed some 2000 exhibitors and Press representatives, and a very pleasant social evening was spent.

On Sunday morning, April 28, a festive opening ceremony was held in the main restaurant, which was filled with guests. The proceedings opened with a rendering of Bizet's Pastorale from the l'Arlesienne Suite, played by the Niedersächische Symphony Orchestra, conducted by Dr. Helmuth Thierfelder. Minister Alfred Kubel then welcomed all in the name of the Deutsche Messe und Austellungs A.G. He reviewed the growth of the Fair, and made reference to the recent extensions to the Messe House and the new Hall 17, designed and built for the office equipment and machinery section. He also spoke of the new iron and steel buildings already referred to, and said that out of the some 4000 firms exhibiting at the Fair nearly 500 were from other lands. Senator F. H. Harms spoke about the fine new hall for office equipment and machinery, which, he said, represented an industry in Germany employing about 70,000 people. Professor Dr. Rodenstock then dealt with precision work and the optical industry.

Professor Dr. Ludwig Erhard, the Minister of National Economy, declared the Fair of 1957 open, and spoke of trade and economics in Germany and in Europe, and the good work being done by the Hanover Fairs. The ceremony closed with Wagner's Introduction to the Third Act of " Lohengrin."

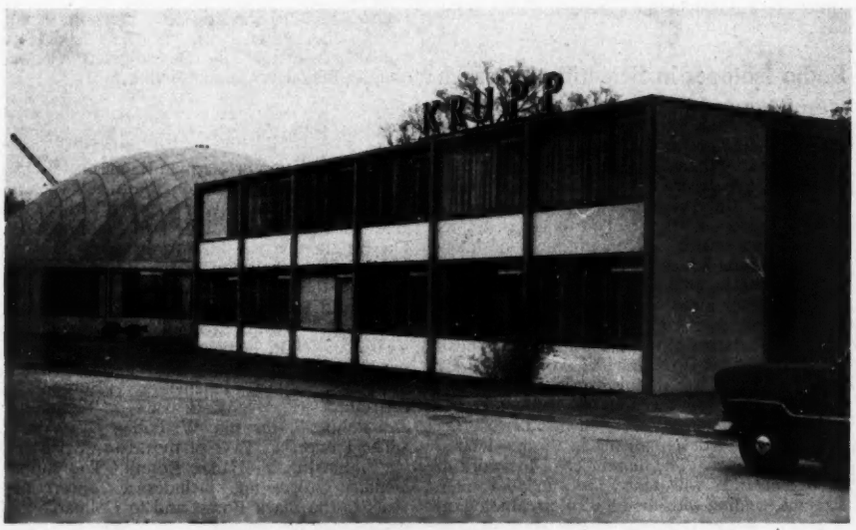


Fig. 1—The new Fried Krupp building

Kampnagel Aktiengesellschaft

An exhibit which dominates the open air exhibition space is the level luffing crane by the Kampnagel Aktiengesellschaft. of Hamburg-Lübeck, a view of which will be seen in Fig. 3. It has a lifting capacity of 2400/5000 kg and a maximum radius of 38m. In the foreground is a fully hydraulic ship crane, having a lifting capacity of 3 tons and a radius from 4m to 12m. The large harbour crane is also built as a slipway crane, a shipyard crane, and as a portal crane for floating docks. Level luffing is maintained by the automatic compensation of the length of the load rope, by rotation of the hoisting drum. The simple straight lattice framework jib is in the form of a two-armed lever, the centre of rotation being exactly within the axis through the centre of gravity, so that the weight of the jib is perfectly balanced in each position. The general construction of the crane is clearly shown in our illustration. The crane house accommodates all the electrical machinery and hoisting and slewing gears, and convenient access is given by a staircase and an opening in the floor of the crane house. In the driver's cabin large windows arranged around the driver's seat give an unimpeded view forwards, sideways, upwards and downwards.

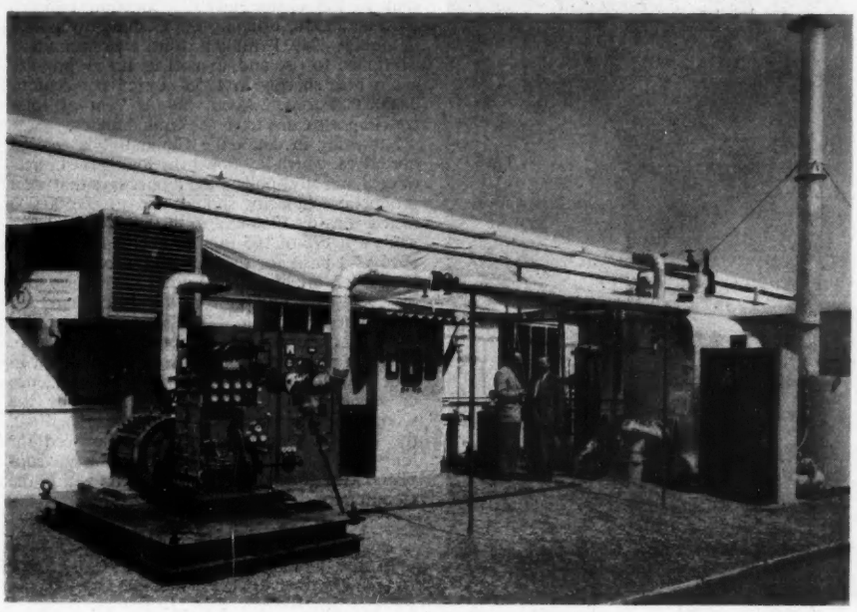


Fig. 2—Heating and power plant—Spillingwerk

Spillingwerk Hamburg

For the first time, the Spillingwerk of Hamburg is showing the interesting design details and patents of its unit-construction steam motor in a slow running 80 b.h.p. twin-cylinder unit. These steam motors cover a power range from 10 b.h.p. up to 1000 b.h.p. in single-cylinder up to six-cylinder units. The cylinder block seen at the Fair is sectioned so that the positions of the piston and the slide valve are clearly seen. The ready exchangeability of the standardised parts can easily be recognised in the sectioned and internally illuminated model, which also shows details of the drive. A four-cylinder unit is also to be seen on the stand.

Of particular interest, however, is the small industrial power station, shown in Fig. 2, which is seen in operation. It is situated between the Messe House and Hall 17, for supplying both power and lighting, and also warm and, later, cold air, and ice, to the adjoining tent restaurant.

This plant has been designed and installed by Dip. Ing. W. Junghans, consulting engineer, of Hamburg, Ferdinand Strasse, 58. The oil-fired boiler was supplied by the Dillinger Maschinenfabrik G.m.b.H., of Dilligen Saar. The pressure of the steam generated is 450 lb per square inch, and the designed output of the boiler is 600 kg of steam per hour. The twin-cylinder Spilling steam motor is a unit with an output of 80 b.h.p., and it is directly coupled to a 50kW generator by Conz, of Hamburg, which firm also supplied the switchboard and switchgear. The air heating is thermostatically controlled and is generated in rotary ventilators

Fig. 3—Large harbour level luffing crane and ships crane—Kampnagel

designed and supplied by Dip. Ing. Gerhard Drews, K.G., of Hamburg. For summer service it is proposed to utilise an absorption type of refrigerator to produce cold air and the ice needed in the restaurant.

(To be continued)

European Coal and Steel Community

With another ten months of the five-year transitional period still to run, the creation of Western Europe's common market in coal and steel is now almost complete. The fifth Annual General Report of the High Authority of the European Coal and Steel Community, published on April 17, states that the only major task unlikely to be completed before the end of the transition period is a thoroughgoing reorganisation of the Belgian coal industry, which has been held up by the boom conditions through which the Community has been passing.

In the report, which has been prepared for presentation to the Community's Common Assembly in time for its annual general session in Strasbourg in the second week of May, the High Authority looks back critically over its achievements, and forward to the new possibilities opened up by the signature of the treaties creating the European Economic Community and Euratom. The High Authority also welcomes the invitation which it recently received from the six member governments to draw up concrete proposals for implementing the common energy policy for the Community recommended in the Spaak Report.

Steel

The Community's outstanding achievement, the report states, was undoubtedly the 36 per cent rise in steel production compared with 1952. This was considerably greater than increases in the same period of 25·7 per cent in the United Kingdom and 23·4 per cent in the United States, although rather less than the rise of 40·8 per cent in the Soviet Union.

Crude steel production rose from 52,600,000 metric tons in 1955 to 56,800,000 metric tons in 1956. The Community's share in world steel production, which had declined regularly between 1929 and 1951, increased from 17·9 per cent in 1951 to 20·1 per cent in 1956, at a time when the share both of the United Kingdom and the United States declined. Steel exports to non-member countries also rose between 1955 and 1956—by 15 per cent to a total of 8,900,000 tons.

Coal

Coal exports, on the other hand, sank by almost half to 5,700,000 tons in 1956. The report stresses the structural deficit of coal in the Community in spite of an increase of 4·2 per cent in the Community's production between 1952 and 1956, bringing the Community's 1956 output to 249·1 million tons. Consumption continued to rise and, to meet its needs, imports again rose sharply in 1956—by 65 per cent to 38,000,000 tons. About 80 per cent of total coal imports came from the United States.

Surveying in detail the Community's general objectives, which lay down the long-term targets of coal and steel policy, the report says that steel production capacity should rise to 73,500,000 metric tons by 1960 and to 86,000,000 by 1965, while a figure of 105 million tons is forecast for 1975 as a basis for the coal and coke estimates. Coal needs are likely to go up to 308 million tons by 1960, 332 million tons by 1965, and 362 million tons by 1975. The report envisages a sharp increase in pig iron output, and intensive researches in new techniques of steelmaking, in order to cut down the Community's dependence on external sources of scrap. Faced by the rising need for iron ore, especially after 1960, the High Authority also stresses the need for long-term contracts with potential foreign suppliers, as well as increased production within the Community.

Investment Policy

In the Community's steel industry, whose future investment projects total considerably more than the average of 550 million dollars a year invested between 1952 and 1955, the shift in investment from rolling mills to pig iron and steelmaking is notable. The report shows the following breakdown of investment declarations presented by steel firms for the years 1957 to 1960 (with percentages for actual investments in 1952–55 in parentheses) : pig iron 31·5 per cent (15·9 per cent), steel 16 per cent (13·8 per cent), finished steel products 33 per cent (35·7 per cent), general services 19·9 per cent (16·6 per cent).

In the coal industry, investments totalling 1687 million dollars for the three years 1957–59 had already been notified to the High Authority at the beginning of 1957 by Community enterprises. This programme, however, although substantially greater than actual investments in the preceding three years (1271 million dollars), is considered far from adequate to fulfil the targets laid down in the general objectives for coal.

Radio Isotopes in Scientific Research

An international conference on radioisotopes in scientific research has been convened by Unesco and will be held in Paris from September 9 to 20. More than 1000 scientists from all over the world are expected to attend. Participants will include those nominated by governments ; representatives of the United Nations or its specialised agencies ; representatives of international scientific organisations; and persons participating in an individual capacity, or sent by scientific or industrial bodies.

The conference will be strictly scientific in character. Its main purpose will be the exposition and discussion of new ideas or methods for the utilisation of radioisotopes in scientific research. Plenary meetings of the conference will be devoted to new developments in measuring techniques and developments in the production of radioisotopes. The remainder of the work of the conference will take place in two main sections, dealing with the physical and biological sciences. A final selection of the papers will be made by the Unesco Secretariat, with the advice of a group of consultants. Proceedings of the conference, including texts of papers and discussions, will be published by Unesco in due course.

Further information about the conference may be obtained by intending participants from the United Kingdom National Commission for Unesco, Ministry of Education, Curzon Street, London, W.1.

Oily-Water Separation

Last month the Netherlands Dock and Shipbuilding Company, Amsterdam, Holland, opened its oily-water separating and tank cleaning installation. The new amenities consist of a harbour, sited at the western end of the company's repair yard, having a concrete jetty fitted with Mannesman mooring fenders, and there are two storage tanks each of 500 tons capacity, to hold the ship's bunkers while repairs, if required, are being carried out. After mooring alongside, non-gas-free and dirty ships are connected up by a set of 8in hoses to the 16in water ballast and 8in slop pipelines on the jetty. The ballast and slops can be pumped ashore at a maximum rate of 1200 tons per hour through the A.P.I. oily-water separator. A tanker having used the Butterworth system while still at sea will be empty and dry in about eight to twelve hours, depending upon the volume of ballast and slops to be dealt with. Adjacent to the oily-water separating plant and pumphouse is a boiler-house equipped with a Yarrow water-tube boiler generating steam at 400 lb per square inch and 445 deg. Fah., a low-pressure boiler delivering steam at 180 lb per square inch and Butterworth heaters and pumps. For tank cleaning purposes, hot water at 185 deg. Fah. and live steam at 180lb per square inch are available. The yard employs its own tank-washing machines and the time required for the operation ranges from twenty-four to forty-eight hours.

International Pressure Die Casting Conference

During the period May 20–24, the Second International Pressure Die Casting Conference is scheduled to take place in Paris. The programme is being organised by the Syndicat General des Fondeurs de France for the European Pressure Die Casting Committee. Papers to be discussed will be available in English, French and German, and simultaneous translation into these languages will take place in all sessions. Topics will include research work on alloys, the die casting process, and the use of die castings, as well as production trends in the industry. A large display of French and American die castings will be on view, some 1000 items having been specially sent from the U.S.A. After the end of formal business on May 22, visits will take place to leading French die casting works and to the Renault car factory. The conference fee is Fr.15,000 ; those wishing to enrol should write to the Syndicat General des Fondeurs de France, Section Fonderie sous Pression, 2, rue de Bassano, Paris (16e). Further details are available from the Zinc Development Association, 34, Berkeley Square, London, W.1.

Technology and World Structure

The Association of German Engineers (V.D.I.) is arranging a conference to be entitled " Technology in the Service of World Order," which will take place on May 28 and 29 in Freiburg i. Br. The programme will be introduced by Dr.-Ing. H. Goeschel, chairman of the V.D.I., and will comprise the following lectures : " Technology and World Unity," (Dr.-Phil. H. E. Holthusen, Munich), " World Economic Preview of the Year 2000 " (Dr. F. Baade, Kiel), " Problems of the Near and Far East " (Dr.-Phil. G. Wirsing, Stuttgart), " Les Ingénieurs, l'Europe et l'Afrique " (P. Wigny, Brussels), " Technology and Politics " (Dr.-Ing. W. Pohle, Düsseldorf), " The Pioneering Task of the Moral Sciences " (Prof. Dr.-Ing. S. Balke, Bonn). The supplementary programme includes a concert and visits to the Black Forest and to Colmar. Full details may be obtained from Verein Deutscher Ingenieure, Pressestelle, Düsseldorf, Prinz-Georg-Strasse 77/79, German Federal Republic.

Experimental Boiling Water Reactor at the Argonne National Laboratory

BY OUR AMERICAN EDITOR

No. III—(*Concluded from page 663, April 26*)

The experimental boiling water reactor (EBWR) at the Argonne National Laboratory, of Lemont, Illinois, was officially dedicated and went on the line in February, 1957. It is the first unit within the power reactor programme of the U.S. Atomic Energy Commission to be completed. The pile produces 20MW of heat, which, in turn, is used to generate 5MW of electricity for consumption at Lemont. The relatively small plant is mainly intended to study and to demonstrate the practicality of direct-cycle boiling water reactors for power generation purposes. Initially, ordinary water is used in the reactor circuit, but it is planned to change over to heavy water in the future.

THE power plant building steel shell is designed to withstand a maximum negative pressure of 0·5 lb per square inch. To prevent negative pressures exceeding this amount, two vacuum breaker valves are provided. There are various other pemanent penetrations through the building shell for water, steam, air and electric cables, pipes and control leads. All are sealed pressure-tight.

The cylindrical portion of the steel shell below the main floor is lined with a 2ft thick reinforced concrete liner. The bottom head is lined with two conical sections which approximate the ellipsoidal shape of the head down to the basement floor slab. Above the main floor, to a height of approximately 26ft, the shell has a 1ft thick reinforced concrete liner. The ceiling slab at this height completes the concrete envelope. This slab has a ¾in thick steel plate on the underside and is 1ft thick. Wherever openings occur in the concrete envelope, missile barriers of 1¼in thick mild steel plate are provided. For exposed areas, such as the air-locks, labyrinthine protective walls of concrete 12in thick are provided. Such shielding protects the shell against damage in case of accident, such as turbine rotor disintegration, or any other sort of accident that would produce flying missiles.

A 20-ton circular travelling bridge crane is provided above the main floor. This crane services the main floor area directly, and the floors below, by way of a 10ft by 15ft hatchway through the main floor. The power plant building is ventilated and heated and air-conditioned by means of four package units. One of these units draws fresh air in from the outside, normally about 3000 cubic feet per minute, which is mixed with the recirculating air through adjustable dampers. The air displaced by the fresh air drawn in through the air intake by the unit on the main floor is discharged through an exhaust stack. This stack exhausts from a point above the ceiling slab, and thence through the roof of the building. To prevent the out-leakage of radioactive gases or dust in case of accident, both the air intake duct and the exhaust stack are equipped with automatic tight shut-off dampers. These dampers are weight-operated and are held open by solenoid-actuated latches which release upon de-energisation to allow the dampers to swing shut. The dampers are actuated by radioactivity monitoring instruments which are adjusted to act at a predetermined maximum activity level of the atmosphere in the power plant building. The dampers, therefore, close automatically in case of an increase in radioactivity in the building above a predetermined safe level, or in case of power interruption.

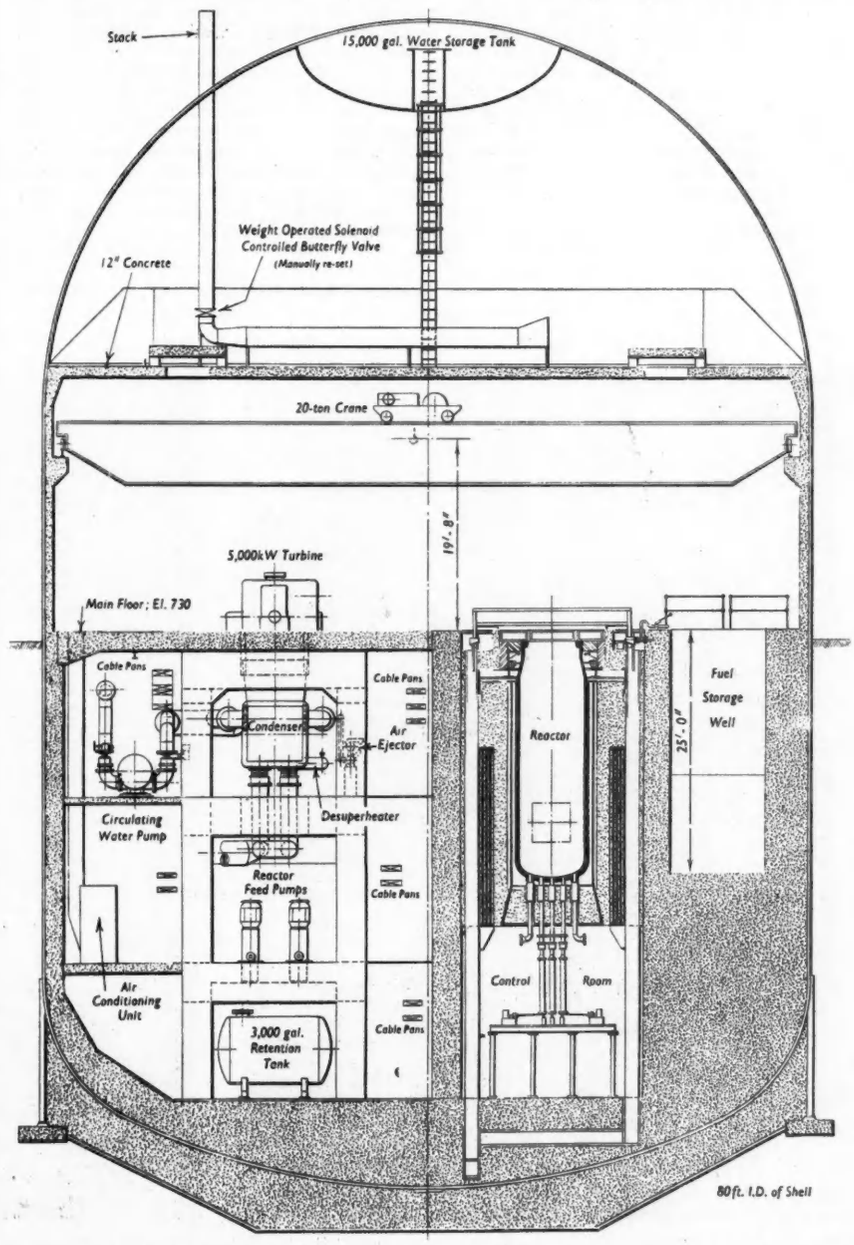
The service building is of steel frame with face brick and concrete block construction, with poured concrete foundations. There is a platform provided for an outdoor high-voltage transformer and switchgear. The entry to the power plant building is through the main air-lock at the end of the corridor directly in line with the main entrance to the building. The plant control room, which is air-conditioned, is situated on the main floor. This room is the centre of operations for the entire plant. The office, locker rooms, laboratory and service room are also on this floor. The basement contains the electrical and mechanical equipment rooms.

Construction of Power Plant

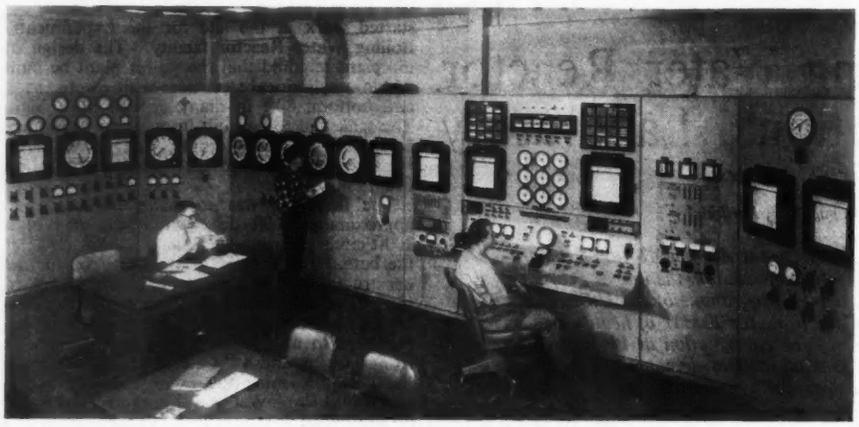
On May 27, 1955, the Sumner Sollitt Company, of Chicago, Illinois, as general contractor, started work at the site for the Experimental Boiling Water Reactor facility. The design of the plant required that the power plant be built within a cylindrical steel tank with elliptical top and bottom, 80ft in diameter and 119ft high. The tank had to be built in place on temporary columns 56ft below grade, and tested as a pressure vessel before any other construction could take place.

The first step was to make an excavation approximately 70ft deep within the area of a 200ft circle at ground level and a 100ft circle at the base. The element of speed desired for the construction of the facility made the choice of the excavation method very important. Employing an open cut, 35,000 cubic yards of dirt were moved with a 1½ cubic yard dragline working from the rim, and a "Caterpillar" bulldozer in the hole. Keeping the excavation dry was a major problem. Wet gravel pockets from which water drained were encountered as the excavation progressed. This, together with additional thousands of gallons from direct rainfall, had to be pumped up some 70ft in sufficient volume to maintain dry, workable conditions.

After completing the excavation, the next step was to install a concrete mat in the bottom of the hole, upon which the erectors of the steel shell of the vessel could work. This steel shell



Sectional elevation of EBWR power station building showing arrangement of concrete and structural steelwork



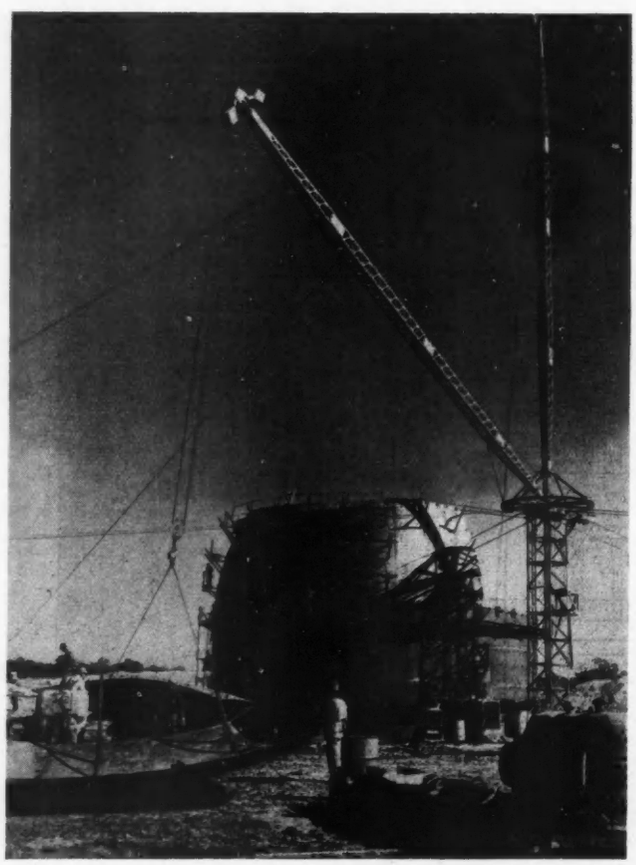
Control room of the EBWR power station with reactor control console

was to be supported on columns bearing on sixteen concrete footings which were installed near the bottom of the excavation. Thus, approximately one-half of the steel shell was put below ground. Upon completion of the concrete footings, the field fabrication of the steel shell was started by the Graver Tank Company, of East Chicago, Indiana. The plates for the semi-ellipsoidal bottom, measuring 80ft in diameter by 20ft deep, were automatically welded into large sections before being set in place. Automatic welding on the horizontal seams of the cylindrical shell, 80ft in diameter by 59ft high, also expedited construction. The self-supporting hemispherical roof, 80ft in diameter and 40ft high, completed the structure. The field work was maintained around the clock, twenty-four hours a day, during the welding phase, in order to finish the vessel before the onset of winter, 1955.

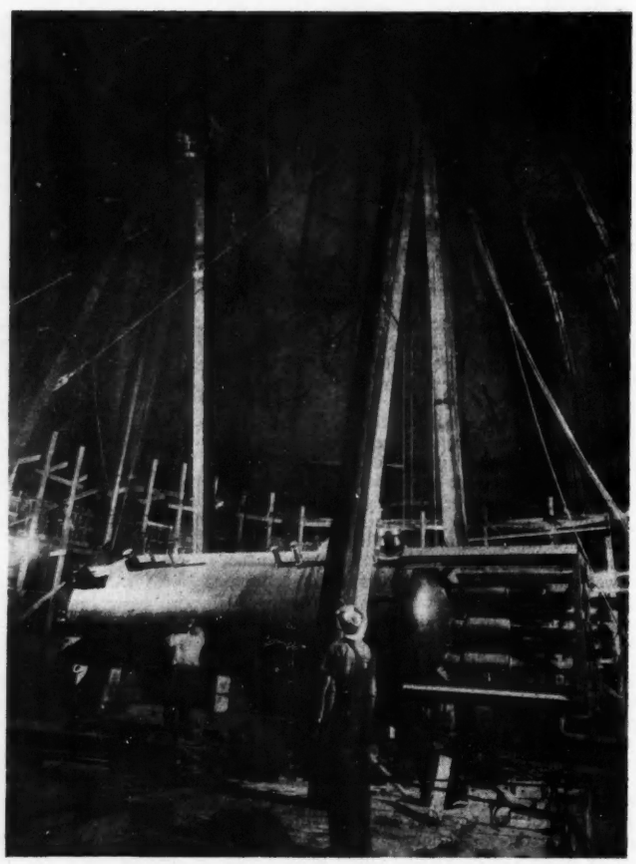
Since the purpose of the containment vessel is to keep any possibly radioactive steam or air leakage from escaping to the outer atmosphere, the fabricator was required to prove that the whole vessel was airtight. With a vessel enclosing 500,000 cubic feet of air, the problem was to secure valid measurements despite the many variables existing in all the atmospheric changes of day and night temperatures, the warmth of the sun, the cooling of wind and rain, humidity variations, and the rise and fall of the barometer. Despite these variables, the tests were concluded successfully. When the steel shell was finished, it was pressurised to about 10 lb per square inch gauge. All welds were painted with a thick soap solution and observed for bubbles or flaking that would indicate leaks. None were found. The pressure was then increased to 18¾ lb per square inch gauge for a strength test. Again, the shell proved satisfactory. Next, the shell was pressurised to approximately 15 lb per square inch gauge and sealed. Temperature and pressure measurements were taken over a period of eight days. These indicated the leakage to be less than 100 cubic feet per twenty-four hours—considerably less than the specification allowance of 500 cubic feet per twenty-four hours.

During the following weeks, the excavation had to be kept dry and preparations made to begin concrete work on the inside of the vessel once it was completed. The only access to the inside of this vessel, after it was pressure tested, was a 13ft by 13ft temporary opening cut into the side at ground elevation. This presented the problem of transporting men and materials to the inside from the bank of the excavation, which was 60ft away. This temporary opening was still approximately 60ft above the bottom of the shell on the inside. Since it was not practical to backfill against the shell until it was lined with 2ft of concrete on the inside, approval was obtained to cut a 4ft by 10ft opening about 35ft below ground level on the side where the concrete footings for the service building were to be installed. This greatly facilitated access for men and materials.

Upon completion of a satisfactory pressure test, operations were commenced for the pouring of the mass concrete footing under the power plant shell. This footing could only be constructed to a predetermined level in order to prevent distortion of the shell. Once this initial concrete was poured, the next pour was inside the shell, which consisted of a basement floor varying in thickness from 7ft 6in to 9ft. Such items as reactor columns, cross-tie beams, drain lines and sump and lift pits had to be installed in the floor. Upon completing the first section of basement floor, concrete was again poured under the steel shell, and by alternately pouring inside and outside, the entire rounded bottom of the shell was brought to bear on a concrete base. Then, all sixteen columns were cut in order to transfer the entire weight of the vessel to the concrete base. The problem of placing concrete inside the vessel was solved by pumping from ground level down the slope of the excavation into the interior where curved sections of pipe carried the concrete around the circumfer-



Site erection and welding of steel plate containment vessel at Lemont



Erection of reactor pressure vessel within steel shell containment vessel

ence of the walls. All concrete inside the vessel was heavily reinforced with steel. To avoid any direct tie of the concrete to the steel shell, a coal tar coating had to be applied before any reinforcing steel or concrete could be placed. Special ties to hold the concrete forms had to be devised and installed prior to the corrosion coating. As the interior walls of the vessel were poured, it was necessary to construct and pour the six turbine foundation columns, the foundation for the reactor fuel storage well and the reactor foundation. These foundations involved pouring heavy masses of concrete.

As concrete work progressed from the basement up, it was necessary to install shoring for not only the intermediate pump and condenser floors, but also for the main floor which was poured at ground level. The main floor, 80ft in diameter, varied in thickness from 2ft to 4ft, poured monolithically. The major portion of this floor had to be shored from the basement floor, and the height of shoring varied from 44ft to 46ft. Some 480 cubic yards of concrete were placed by three pumps and by concrete carts in less than eight hours, completing the major concrete work up to ground level. While work progressed inside the vessel, the service building foundations adjacent to the vessel were being installed. Backfilling operations were carried on as the concrete work progressed. It should be noted that much of the concrete work was accomplished under winter conditions, and to protect the concrete which was being placed inside the shell against cold steel, the entire outside of the shell up to ground level had to be insulated, with steam heat employed inside, to provide the proper temperature for pouring.

Upon completion of the main floor of the power station, work in the reactor installation proceeded. Considerable time in installing the heavy steel columns and bases for the reactor pressure vessel was saved by using a crawler crane weighing about 100 tons and operating it on the concrete floor of the power station. The installation of the reactor proceeded in definite sequence. The installation of the bottom plug was accomplished by lowering the hollow plug shell down some 33ft into the reactor foundation well on to previously erected timber shoring bearing on the basement floor. This shoring of 10in by 10in timbers was laid out to support an estimated load of approximately 250 tons. With the bottom plug shell resting on the shoring, the reactor vessel itself was ready to be lowered into the well. The reactor vessel was approximately 23ft long and 8ft in diameter. The limited working space precluded using a crane. It was necessary to bring the vessel through the temporary opening on a skid over rollers, raise it to an upright position and lower it into the well with two sets of "A" frames, one of which towered over the reactor well some 50ft. With the reactor set on to the supporting steel in the well, the bottom plug was adjusted to the nozzles on the bottom of the reactor and raised to its final position. Using a crane and a ¼ cubic yard concrete bucket, the bottom plug was then filled with approximately 15 cubic yards of heavy shielding concrete. Upon completion of pouring the bottom plug, it was necessary to shield the reactor with lead brick and install cooling piping. When this phase was completed, the next step was to pour heavy concrete between the reactor and the foundation well to act as a dense shielding.

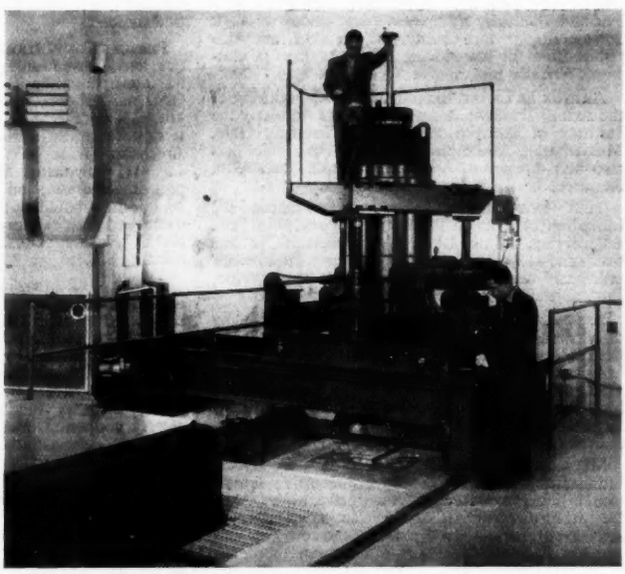
As work was proceeding on the reactor, work in the service building and cooling tower to the rear of the power station continued. Installation of mechanical equipment and pipework proceeded on an accelerated scale, after the main floor was poured and the shoring removed. At this point considerable work by the electrical subcontractor was begun. While installation of the reactor was proceeding, the inside of the top of the shell was lined with 1ft thick concrete. This inside lining was poured in sections, up to a point where a concrete haunch was made to hold a circular rail on which the 20-ton travelling bridge crane was installed, 19ft above the floor. The concrete lining rose still further to a point some 27ft above the main floor, where another haunch was provided around the circumference of the power station. At this point two trusses, 13ft high and spanning 74ft, were placed 25ft apart, bearing on the concrete haunch.

Reactor Operation

Loading a reactor and bringing it up to power requires the utmost care. Tests with the EBWR to date have shown that it behayes reliably and according to expectations. During operation, cold feed water at 110 deg. Fah. is pumped into the reactor vessel, where its temperature is raised to 488 deg. Fah. at a pressure of 600 lb per square inch gauge. At 20MW core power the corresponding steam generation rate is 60,600 lb per hour, which is reduced to 60,000 lb per hour with the reactor water purification system in operation ; about 150kW of heat is rejected by the purification system. Approximately 35 per cent of the heat of fission is expended in raising the cold feed water to saturation condition at 488 deg. Fah. and the remaining 65 per cent forms steam.

The steam rises through the vessel to the steam collection ring at a rate of 0·39ft per second. Although the total impurities in the reactor water are kept down by the purification system, some irradiated impurities will be carried over. To minimise this carry-over, the steam collection system is designed to avoid the entrainment of water droplets.

Irradiated fuel assemblies and control rods can be transferred from the reactor to the water-filled storage well in a lead-shielded coffin. Ports in eccentric rings in the top shield plug afford access to each fuel assembly and control rod position. The units are pulled up into the coffin. A leakproof door on the bottom of the coffin may be closed so that the coffin may be filled with water to cool the elements during transfer, if necessary. The storage well to which the units are transferred is a water-filled pit, 25ft deep, situated adjacent to the reactor. Here the units will be cooled until they can be removed for reprocessing.



Lead coffin and carriage for the transfer of irradiated fuel assemblies and control rods from the reactor to the storage well

The EBWR holds an important place in the A.E.C. power reactor programme, not only by virtue of its being the first such reactor to be completed, but also because it offers a promising approach to economical nuclear power. The simplicity of the boiling reactor design, offering the possibility of avoiding heat exchangers, and the inherent safety characteristics of the system, give the EBWR a special significance in the development of nuclear power. Based on data already obtained from the Argonne National Laboratory boiling water experiments, the Commonwealth Edison Company, of Chicago, with a group of associated companies, is now planning a boiling water reactor plant at Dresden, Illinois, which will produce 180MW of electricity. Another boiling water power reactor to produce 22MW is being planned by the Rural Co-operative Power Association for construction at Elk River, Minnesota. The General Electric Company is building a reactor, similar in many respects to the EBWR, at Valecito, California, to carry on its programme of private industrial nuclear development.

Large Vacuum Impregnator for the Pakistan Railways

One of the largest vacuum impregnating systems ever built in the United States will shortly be placed in service by the Government of Pakistan Railways at Karachi. The equipment will be used to impregnate with insulating varnish the armatures and field coils of diesel-electric locomotive traction motors, a step which increases the service life and reliability of these components. The system received its final inspection recently at the Philadelphia works of its builders, the F. J. Stokes Corporation, just prior to its dispatch abroad from the Port of Philadelphia.

Impregnation with the aid of vacuum ensures a deeper and more thorough penetration of the insulating varnish into the tiny crevices between the thousands of turns of wire that make up the electrical windings of these motor components. As a result, electrical and mechanical breakdowns are reduced and the service life of the motors between overhauls is considerably lengthened. One of the two tanks—the impregnating chamber—is 58in inside diameter and nearly 9ft tall, with a maximum immersion height of 87in—deep enough to cover fully the longest armatures. The components to be impregnated are lowered into this chamber, the hinged lid is closed and sealed, and vacuum is then drawn within the chamber by pumping out virtually all of the air. Along with the air go the last traces of moisture that may have been clinging to the inner surfaces of the electrical windings. When all the air and moisture have been sucked out, the impregnating liquor, a "Glyptal" insulating varnish, is admitted to the vacuum chamber by opening a valve in the pipe which connects the chamber with the 1120-gallon storage tank at the right. The varnish rises in the impregnating chamber until it completely covers the motor components. Thanks to the absence of air, the varnish penetrates deeply into the windings. Air under pressure is then applied to the surface of the varnish "bath" to accelerate the penetration of the varnish into the windings. The armature or the coil is then removed from the vacuum chamber and the varnish is dried to maximum hardness by baking it slowly for sixteen to eighteen hours at a temperature of 140 deg. to 150 deg. Cent. The treated component then gets a further coat of red enamel "Glyptal" varnish by dipping it and then baking it for another twelve to eighteen hours at 120 deg. to 150 deg. Cent.

Soil Engineering in Frost Areas.—The Massachusetts Institute of Technology is organising a summer programme of studies (June 11 to 21, 1957) on soil engineering in frost areas. The subject matter will include engineering implications of glacial geology, frost problems in Canada, principles of heat flow, and of soil freezing, frost action and soil stabilisation. There will be a study of frost criteria on the design and construction of embankments, walls, foundations and highways. Residential accommodation is available. More information can be obtained from M.I.T. Summer Session Office, Cambridge, 39, Mass.

Personal and Business

Appointments

MR. J. E. C. BAILEY has been elected chairman of the British Scientific Instrument Research Association.

MAJOR-GENERAL SIR RICHARD G. LEWIS has been appointed to the board of Associated British Engineering, Ltd., as a non-executive director.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., has announced that Dr. J. N. Aldington and Sir Nicholas Cayzer have been appointed directors.

BLACK AND DECKER MANUFACTURING COMPANY, Ltd., Toronto, has announced the appointment of Mr. Drummond R. Stuart as general manager.

THE TURRET GRINDING WHEEL COMPANY, Ltd., states that Mr. H. C. Belchamber has been appointed works manager and Mr. D. P. Malton technical manager.

JAMES HOWDEN AND CO., Ltd., has announced that Mr. J. D. Howden Hume and Mr. J. D. Young have been appointed directors, and Mr. J. S. A. Pearson and Mr. N. Zoller local directors.

MULLARD, Ltd., has announced that Mr. A. D. Priestland, M.I.E.E., and Mr. P. E. Trier, A.M.I.E.E., have been appointed directors of the Mullard Radio Valve Company, Ltd.

MR. J. D. MORTON, M.I.Mech.E., M.I.E.E., has been appointed managing director of Siemens-Schuckert (Great Britain), Ltd., following the retirement of Mr. A. E. Barton.

THE BRITISH WELDING RESEARCH ASSOCIATION has announced that Dr. Richard Weck, A.M.I.C.E., A.M.I.Mech.E., has been appointed director of research with effect from June 17.

MR. J. E. RICHARDSON, deputy general manager and engineering manager, Barrow Works, Vickers Armstrongs (Engineers), Ltd., has been appointed managing director of Canadian Vickers, Ltd.

THE MINISTRY OF HOUSING AND LOCAL GOVERNMENT announces that Colonel H. Haswell Peile has been appointed chairman and Alderman W. Baines deputy chairman of Peterlee New Town Development Corporation.

MR. G. R. PETERSON, M.I.E.E., M.I.Mech.E., deputy chief engineer (generation and system operation) of the Central Electricity Authority, has been appointed deputy chief executive of the Federal Power Board of Rhodesia and Nyasaland.

A.C.V. SALES, Ltd., states that Mr. A. S. C. Chattey has been appointed chairman and Mr. P. Rackham a director. Mr. Chattey has been invited to join the board of the parent company, Associated Commercial Vehicles, Ltd.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND states that the following office-bearers have been elected for the session 1957–58 :—president, Professor James Small ; vice-presidents, Mr. H. R. Gibbs and Mr. G. Johnson.

THE MINISTRY OF SUPPLY, with the agreement of the War Office, has announced that Colonel C. A. Zweigbergk has been appointed director, inspectorate of electrical and mechanical equipment, and on taking up this appointment will be granted the acting rank of Brigadier.

BRYMBO STEEL WORKS, Ltd., announces that Mr. Esmond Morse has resigned from the chairmanship of the company and the board of directors. Mr. K. S. Peacock has been appointed chairman and Mr. D. Bruce-Gardner and Mr. C. R. Wheeler have been appointed directors.

MR. DAVID P. RANSOME, M.I.Mech.E., M.I.B.A.E., past-president of the Institution of British Agricultural Engineers, and of the Agricultural Engineers' Association, has been appointed the industrial investigator in the Ministry of Commerce and Industry of the Federal Government of Rhodesia and Nyasaland.

THE INTERNATIONAL CHAMBER OF SHIPPING announces that at its annual meeting, held on April 5, Sir Colin Anderson was re-elected chairman for a further period of two years, and Mr. Birger Krogius (Finland) was re-elected a vice-chairman, while Mr. C. H. Kemp (U.S.A.) was elected a vice-chairman.

ALUMINIUM, Ltd., announces that Mr. F. W. Bruce has been appointed president of the Aluminium Company of Canada, Ltd., and has been succeeded as managing director of the Northern Aluminium Company, Ltd., by Mr. S. E. Clotworthy, the sales director. Mr. M. P. Weigel has been appointed director of operations of Aluminium, Ltd., in succession to Mr. R. E. Powell, who was re-elected a director of Aluminium, Ltd., and of the Aluminium Company of Canada, Ltd. Field Marshal Earl Alexander of Tunis has been elected a director and chairman of the Northern Aluminium Company, Ltd.

Business Announcements

BRITTEN-NORMAN, Ltd., states that it has acquired the lease of Bembridge Airport, Isle of Wight.

LANCASHIRE DYNAMO NEVELIN, Ltd., Hurst Green Oxted, Surrey, states that its telephone number has been changed to Oxted 3361.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that the telephone number of its Huyton Quarry Works has been changed to Huyton 4591–3.

MR. F. L. PETTMAN, a director of Temperature, Ltd., is leaving London by air on May 21 for an extended tour of the Middle East and Pakistan.

H. LEVERTON AND CO., Ltd., Spalding, Lincs, has announced the formation of a new subsidiary company, Leverton of Leeds, Ltd., Gelderd Road, Gildersome, Leeds.

THE BRITISH SCIENTIFIC INSTRUMENT RESEARCH ASSOCIATION has announced the formation of an automatic control research panel under the chairmanship of Mr. A. J. Young.

STANDARD TELEPHONES AND CABLES, Ltd., states that its cables sales office and warehouse has been moved from 16, Hockley Street, Birmingham, to 48, Kenyon Street, Birmingham.

ACROW (ENGINEERS), Ltd., states that it has concluded an agreement with the Demag Group, Germany, whereby it will look after the Demag-Zug interests in the United Kingdom.

LONDEX, Ltd., Anerley Works, 207, Anerley Road, London, S.E.20, states that its telephone number has been changed to Sydenham 3111, and the number at its main works to Sydenham 6258.

MR. A. J. HARRIS states that he has taken into partnership his brother, Mr. J. D. Harris, and that the practice will henceforward be known as A. J. and J. D. Harris, chartered civil engineers.

THE A.E.I. LAMP AND LIGHTING COMPANY, Ltd., has announced that its Croydon Area Stores, 54, Selsdon Road, Croydon, has been closed and that correspondence should now be addressed to 44, Fitzroy Road, London, N.W.1 (telephone, Primrose 7750).

THE PLESSEY COMPANY, Ltd., Ilford, Essex, states that it has concluded a licensing agreement with Farrand Controls, Inc., New York, under which it will develop in this country for the next two years applications for the existing Farrand system of electronic machine tool control.

ARTHUR D. LITTLE, Inc., announces the opening of the Arthur D. Little Research Institute (formerly the Institute of Seaweed Research) at Inveresk Gate, Musselburgh, Midlothian, Scotland. An office has also been opened at Avenida Ponce de Leon 1510, Santurce, San Juan, Puerto Rico.

TUBE INVESTMENTS, Ltd., has announced the formation of a new subsidiary company, Old Park Engineering, Ltd., of Dudley, Worcestershire, to take over general welded fabrications and structural work previously carried out at Round Oak Steel Works, Ltd., and at the New Conveyor Company, Ltd.

ASEA ELECTRIC, Ltd., states that the Asea Company of Vasteras, Sweden, and the Brush Group, Ltd., have made an arrangement whereby the Brush Group has acquired the equity of Asea Electric, Ltd., of Walthamstow, also trading as Fuller Electrical and Manufacturing Company, Ltd. Mr. Ian Morrow has become chairman and Sir George Briggs, vice-chairman of the company.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., states that the address of its transformer department is now Floats Road, Wythenshawe, Manchester, 23. It further states that the traction department has been organised as a division of the company and that Mr. F. Whyman, M.I.E.E., has been appointed chief engineer, traction division, in addition to his duties as chief engineer, traction projects department.

Contracts

D. NAPIER AND SON, Ltd., announces that the company is to build two eighteen-cylinder "Deltic" engines for the "Fort" class patrol cruiser for the Royal Canadian Mounted Police. The cruiser will have a length of 120ft and a speed of more than 20 knots, and will be built by Kingston Shipyards, Ltd., Kingston, Ontario.

SMITH'S DOCK COMPANY, Ltd., has received an order from France Fenwick and Co., Ltd., to install a set of free piston-gas turbine machinery in the cargo ship s.s. "Goodwood." Smith's Dock Company, Ltd., is to build the free-piston gas generator, while the turbine will be built in France and the reduction gearing in Germany.

Miscellanea

INSTITUTION OF CHEMICAL ENGINEERS.—The Queen has approved the grant of a Royal Charter to the Institution of Chemical Engineers. The Institution was founded in 1922 ; its membership is now about 3500.

MR. W. IVAN WALTERS.—We record with regret the death of Mr. W. Ivan Walters, which occurred on April 13, at the age of sixty-six. Mr. Walters was the founder and chairman of the Walterisation Company, Ltd., Croydon.

NATIONAL SOCIETY FOR CLEAN AIR.—At a special general meeting of the National Smoke Abatement Society held in London recently, it was unanimously agreed that the society should seek incorporation as a company, limited by guarantee and without share capital, and with the new name National Society for Clean air.

PATENT APPLICATIONS.—The Board of Trade has laid before Parliament rules under the Patents Act, 1957, specifying the period within which an application for a patent must be put in order for acceptance. As was foreshadowed during the debates on the Act, the period laid down is three years six months from the date of filing the complete specification.

OIL REFINERY FOR TURKEY.—We are informed that a group of companies, including Mobil Overseas Oil Company, Inc., the British Petroleum Company, Ltd., California Texas Corporation, and the Royal Dutch Shell Group, is to build an oil refinery in Turkey. The refinery will have a capacity of 65,000 barrels per day and the initial installation will be a crude petroleum distillation unit and a catalytic reforming unit.

STUDY TOUR OF GERMANY.—Last week a party of forty executives representing various industries in this country began a "study tour" of German industry. The tour has been arranged by the Industrial Welfare Society, one of the objects being to provide an opportunity for management representatives to examine industrial systems that are not too diverse from those in this country. The British delegates are also studying such matters as the German attitude to work, the responsibilities of German managements, and the activities of German trade unions.

PLASTICS CONVENTION.—The British Plastics Exhibition and Convention in 1957 will, for the first time, be international in character. The exhibition, at Olympia, London, from July 10 to 20, will include products from France, Belgium, Germany, Holland, Italy, Sweden, Switzerland, and the United States of America. The subjects of the convention will be, on July 11, polyolefins and polythene ; on July 12, polyvinylchloride ; on July 15, extrusion ; on July 16, injection moulding ; on July 17, material developments and glass reinforced plastics. The organiser is *British Plastics*, Dorset House, Stamford Street, London, S.E.1.

COUNTRY INDUSTRIES EXHIBITION.—A Country Industries Exhibition is to be held at Holland Park, London, from June 1 to 15. The exhibition is being arranged by the Rural Industries Bureau with the co-operation of the London County Council, and the aim is to demonstrate to Londoners the variety of the trades carried on in the countryside. Traditional crafts, such as saddlery, wrought-iron working, pottery, coopering, brick-making and wheelwrighting, are to be demonstrated, and there will be exhibits indicating the several ways in which the Rural Industries Bureau has assisted many of the traditional industries of the countryside to adapt themselves to modern requirements.

FILM OF AIR TRAVEL.—The "Shell" film unit, at the suggestion of the International Air Transport Association, has made a film to show how great is the contribution of aviation to mankind at a time when no two people are more than two days apart. "Song of the Clouds" emphasises particularly the extent of international collaboration involved, tickets and waybills being accepted by all airlines, communications and meteorology being organised on a global plan. Despite its title, the film includes many passages of great technical interest, including the taking off of model and full-scale Convair "XFY–1" "tail-sitter" machines, and the approach of a "Constellation" in bad visibility seen from an aircraft about 150ft behind. Aircraft of the immediate future seen in flight were the Boeing "707," Bristol "Britannia," and Douglas "DC–7.C." The film runs for thirty-six minutes and is in Eastman colour ; it is available, in England and Wales, from the Petroleum Films Bureau, 29, New Bond Street, W.1, and in Scotland from the Scottish Films Office, 16–17, Woodside Terrace, Charing Cross, Glasgow, C.3.

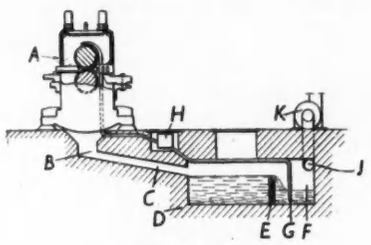
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

METALLURGY

772,276. June 22, 1955.—REMOVING FUMES GENERATED BY ROLLING MILLS, Aktiebolaget Svenska Metalverken, of Västeras, Sweden.

The invention is characterised in a pit for the collection of cooling liquid arranged below each pair of rolls, the pit communicating with evacuating means adapted to maintain sub-pressure in the pit for the exhaust of the smoke, oxide dust, &c., from the set of rolls. The drawing illustrates a set of rolls



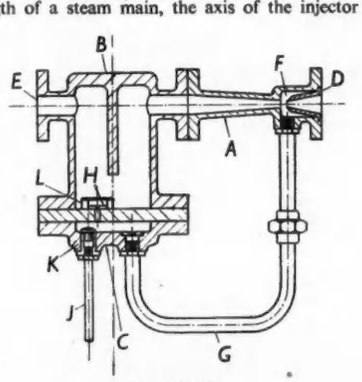
No. 772,276

A, below which is a pit *B* for the collection of cooling liquid. The pit is connected by a duct *C* to a settling basin *D*. In the settling basin is a weir *E* and in the portion *F* of the basin, beyond the weir, is a line *G* for returning the cooling liquid to the rolls by means of the pump *H*. Connected to the basin *D* is a tube *J* for the exhaust of impure air by means of the fan *K*. Arrangements of cooling liquid flow and the full enclosure of the rolls by plates are also shown in the specification.—*April* 10, 1957.

STEAM GENERATORS

772,058. August 10, 1954.—DESUPERHEATER FOR STEAM OR OTHER SUPERHEATED VAPOUR, Alfred Kenneth Porter, 466, Russell Court, Woburn Place, London, W.C.1.

The object of the invention is to provide simple and efficient apparatus capable of substantially completely desuperheating a vapour supply without producing an excess of condensate in the desuperheated vapour. In the description the terms "steam" and "water" are used, but it is to be understood that the description is equally applicable in principle to other vapours and liquids. In use the apparatus is fitted into a horizontal length of a steam main, the axis of the injector *A*



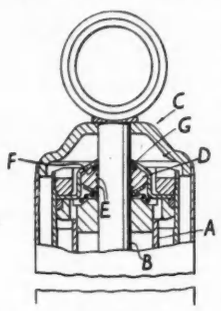
No. 772,058

being in a substantially horizontal position, whereas the axes of the vessels *B* and *C* are substantially vertical. The superheated steam enters through the convergent nozzle *D* of the injector *A* and the saturated steam leaves at the outlet port *E*. The steam passes through the throat of the injector at such high velocity that it induces a partial vacuum in the space *F*, pipe *G* and vessel *C*. Owing to the pressure difference thus created between the upper and the lower vessels, steam passes through the orifice *H*. The quantity of steam passing is, however, so restricted by the smallness and the sharp edge of the orifice and by the critical velocity that the injector is able to suck it into the main stream and still reduce the pressure in the vessel *C* to less than atmospheric pressure. This reduced pressure induces the water to rise through pipe *J*, lift the non-return valve *K* and flow into the vessel *C*. Steam entering the vessel *C* is now condensed by the water, thus maintaining the low pressure. The incoming water with the condensed steam is sucked out of the vessel *C* by the injector and entrained by the steam passing through the divergent nozzle into the upper vessel *B*. The quantity of water so entrained conveniently may be arranged to desuperheat and wet saturate the steam. In the upper vessel *B*, the excess water and condensate is thrown out of the steam and falls to the bottom of the vessel. The steam thus leaves the outlet port *E* as dry, or slightly wet, saturated steam. The water collecting at the bottom of the vessel *B* flows over the weir *L* and through the orifice *H* into the lower vessel *C*. In any practicable application of the apparatus, the weight of water flowing through the orifice *H* in unit time, when the weir *L* is full, is approximately twenty to forty times the weight of steam flowing through the orifice in unit time when the weir is empty.—*April* 10, 1957.

LUBRICATING DEVICES

772,456. August 3, 1954.—LUBRICANT SEALING DEVICES, Woodhead-Monroe, Ltd., Moorcroft Mills, Ossett, Yorkshire. (*Inventors: William Arthur Duckett and William Henry Lloyd.*)

The drawing shows a hydraulic telescopic shock absorber which includes a main cylinder *A* in which a piston slides, the piston being carried by a piston-rod *B* to which one of the anchors of the shock absorber is attached. As is usual, the upper end of the cylinder is closed by means of an assembly designated generally by *C* and incorporating a sealing ring *D*. The sealing ring is, as has been the practice hitherto, provided on its inner surface with inwardly directed annular lips, teeth or the like *E* adapted to engage the piston-rod *B*. In addition, the upper face of the sealing ring is formed with an annular recess *F* formed to accommodate a bearing ring *G*, which is of porous material and impregnated with lubricant. The bearing ring *F* surrounds the piston-rod *B* and by virtue of its impregnation with lubricant forms a lubricant reservoir which ensures that the upper wiping lips or teeth *E* on the seal will not become dry. By reason of the fact that the bearing ring *G* is seated in a recess within the sealing ring *F*, the overall dimensions of the latter will not be increased so that the sealing ring may be employed in any existing shock absorber assembly without any major modification being necessary to existing parts of such assembly.—*April* 10 1957.

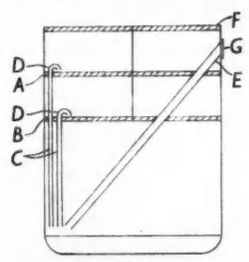


No. 772,456

MARINE ENGINEERING

771,544. October 21, 1954.—A WATER DRAINAGE SYSTEM FOR SHIPS, Edgar Lakeman Trant, Elm House, Halewood Road, Gateacre, Lancashire.

The invention relates to water drainage systems in ships. Its object is to provide an improved drainage system which will minimise to a very considerable extent the dangers associated with accumulations of water in the upper regions of a ship and which will be simple and at least in part automatic in operation.



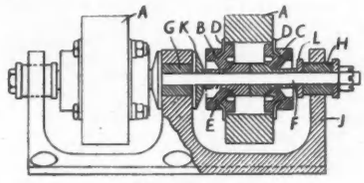
No. 771,544

Referring to the drawing, the drainage ducts descend directly from the upper decks *A* and *B* to the lower parts of the vessel—for example, over the bilge hatches—and at the inlet of each duct *C* on the upper deck level is provided a U-shaped return bend *D*. The number and size of these ducts depends on the amount of water to be dealt with, and they are distributed at strategic positions throughout the length and on both sides of the vessel. The removal ducts *E* are connected, from an inlet in the lower part and diagonally across the width of the vessel, to an outlet above the water line and, preferably, just below the level of the main deck *F*, access to the outlet being obtained through a watertight door or port *G* in the outer plating of the vessel, the door being arranged to be opened from the outside. The removal ducts *E* are of appropriate cross section to permit the passage of suction hoses. They may either be used directly for the pumping out of water from the lower regions of the ship or indirectly as conduits for the lowering of an engine suction pipe down to the level of accumulated water. The ducts may also serve for the introduction of air into a sunken ship to restore buoyancy during salvage operations or for the introduction of non-combustible gas of foam in fire-fighting operations.—*April* 3, 1957.

POWER TRANSMISSION

772,129. October 17, 1955.—VIBRATION DAMPERS, Blackburn and General Aircraft, Ltd., Brough, East Yorkshire. (*Inventors: Alan King*, 2, *Humber Crescent, Brough, East Yorkshire; Ernest Arthur Winn*, 12, *Tranby Avenue, Hessle, East Yorkshire; Colin Graham Saunders*, 138, *Rokeby Park, Anlaby Park Road North, Hull, East Yorkshire, and Robin Hymers Piper*, 13, *Gibson Lane, Melton, North Ferriby, East Yorkshire.*)

The invention relates to a ring vibration damper or absorber having at least 3 deg. of freedom which will effectively absorb vibration in the structure on which it is mounted. As will be seen from the drawing the damper comprises an annulus or ring *A* of any convenient material, such as aluminium, which is carried by two spaced resilient mounts *B* and *C* of natural or synthetic rubber,



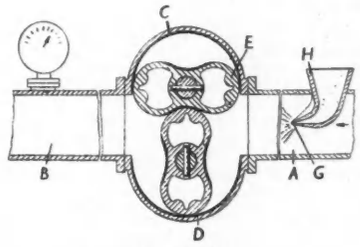
No, 772,129

having moulded in attachment means *D* with a bonded hollow metal core *E*. The attachments *D* are made fast to the ring *A* in any convenient manner. The cores are mounted on a rod *F* which is in turn supported by thermal insulating bushes *G* and *H* in the arms of a mounting bracket *J* by means of which the device is secured to the structure, the vibrations in which are to be absorbed. Washers such as *K* and *L* are provided to locate the mounts on the member *F*. The mounting and the simple annulus *A* illustrated are such that the damper has 3 deg. of freedom in translational directions. The vibration damper may be constructed as a single unit of one annulus or in compound form as illustrated, when the supporting bracket is shaped to carry two annuli *A* and the rod *F* may be common to both.—*April* 10, 1957.

BLOWERS AND COMPRESSORS

772,350. September 13, 1955.—IMPROVING THE VOLUMETRIC EFFICIENCY OF ROOT'S BLOWERS, Hanomag Aktiengesellschaft, Hamelner Strasse 8, Hanover, Germany. (*Inventor: Leo Stankewitz.*)

The invention relates to a method and a device to improve the volumetric efficiency of Root's blowers and, at the same time, shows the particular design of a blower produced in accordance with this method. The blower to be treated is arranged, as shown in the drawing, between an air suction pipe *A* and a pressure pipe *B*. The blower comprises a housing *C* in which the rotors *D* and *E* rotate. A vaporiser *G*, connected



No. 772,350

to a container *H*, is arranged in the air suction pipe. The container is filled with an adhering matter as, for instance, colloidal graphite, varnish, synthetic material, metal, or the like. During the operation of the blower the material is sucked in through the nozzle and vaporised into the air stream, or it may be pressure injected. The air enriched with the adhering matter, is passed through the blower. The sealing matter is deposited on the blower parts where sufficient room is available, i.e. in the zone of the gaps. It is also deposited on the blower housing walls, as well as on the rotors, so that the gaps narrow. If an efficiency is arrived at which seems to be desirable, hot air may be passed through the blower, thus drying or hardening the layer of sealing matter. Then the blower may be taken off the device.—*April* 10, 1957.

Launches and Trial Trips

NORTHBANK, cargo liner ; built by William Doxford and Sons (Shipbuilders), Ltd., for the Bank Line, Ltd.; length between perpendiculars 450ft, breadth moulded 62ft, depth moulded to second deck 29ft 6in, deadweight 10,200 tons on open shelter deck draught ; five cargo holds, one 25-ton, four 10-ton, ten 5-ton and two 3-ton derricks, electric winches ; Doxford opposed piston oil engine, six cylinders 670mm diameter by 2320mm combined stroke, 6180 b.h.p.—Launch, January 31.

STORFONN, oil tanker ; built at Belfast by Harland and Wolff, Ltd., for Sigval Bergesen and Associated Companies ; length overall 660ft, length between perpendiculars 640ft, breadth moulded 86ft, depth moulded to trunk deck 51ft 6in, deadweight 36,000 tons ; thirty cargo oil compartments, ten 'tween deck ballast tanks, one main cargo pump room ; two 800kW, 440V, 60 c/s turbo-alternators, two 250kW, 440V, 60 c/s diesel driven alternators, one 25W diesel driven emergency alternator ; one set of double reduction geared compound turbines, 12,500 service s.h.p. at 112 propeller r.p.m., steam supplied at 450 lb per sqaure inch and 750 deg. Fah. by two Babcock and Wilcox integral furnace watertube boilers.—Trial, January 31.

PENTHIEVRE II, wine carrier ; built by the Chantiers Réunis Loire Normandie for the Compagnie Nantaise des Chargeurs de l'Ouest ; length overall 322ft 6in, length between perpendiculars 310ft, breadth moulded 43ft, depth 22ft 6in, draught 18ft 9in, deadweight 3000 tons, wine tank capacity 550,000 gallons ; one Penhoët - Burmeister and Wain 656VTBF110 diesel engine 3450 h.p. at 150 r.p.m.—Trial, January.

AUGUSTIN LE BORGNE, cargo ship ; built by the Anciens Chantiers Dubigeon for the Compagnie Charles Le Borgne ; length overall 284ft 5in, length between perpendiculars 257ft 7in, breadth moulded 38ft, depth to shelter deck 23ft 5in, draught 15ft 1in, speed 14¼ knots ; hold capacity (grain) 119,450 cubic feet ; two Semt-Pielstick four stroke diesel engines built by the Société Generalé de Constructions, Mecaniques, coupled to a single propeller shaft through a messian reduction gear, 2000 h.p. at 425 r.p.m., 150 propeller r.p.m.—Trial, January.

CRYSTAL CROWN, bulk cargo ship ; built by Smith's Dock Company, Ltd., for the Sugar Line, Ltd.; length overall 460ft 9in, length between perpendiculars 430ft, breadth moulded 61ft, depth moulded to upper deck 37ft 3in, deadweight 9785 tons on a draught of 24ft 6¼in, service speed 12¼ knots ; five main self-trimming cargo holds, wing compartments to carry grain or water ballast, one 25-ton and ten-10 ton derricks, steam cargo winches ; two 75kW diesel driven generators, one 20kW steam driven generator ; Hawthorn-Doxford two stroke, opposed piston diaphragm oil engine, four cylinders 600mm diameter by 2320mm combined stroke, 3300 b.h.p. at 108 r.p.m., one Scotch boiler and one Cochrane composite boiler.—Trial, January.

ALBANY, cargo liner ; built at Govan by Harland and Wolff, Ltd., for the Royal Mail Lines, Ltd.; length between perpendiculars 415ft, breadth moulded 58ft 6in, depth moulded to shelter deck 38ft 4in, gross tonnage 7300 ; three continuous decks, seven watertight bulkheads, five cargo holds, one 30-ton and fourteen other derricks, electric deck machinery ; three 150kW diesel driven generators ; Harland and Wolff two stroke, single-acting, opposed piston diesel engine, six cylinders 620mm diameter by 1870mm combined stroke, 118 r.p.m.—Trial, February 13.

AFGHANISTAN, ore carrier ; built at Govan by Harland and Wolff, Ltd., for the Hindustan Steam Shipping Company, Ltd.; length between perpendiculars 485ft, breadth moulded 68ft 9in, depth moulded 36ft 3in, deadweight 14,500 tons, service speed 11¼ knots ; wing tanks outside holds for water ballast ; three 220kW diesel driven generators, one 40kW diesel driven emergency generator ; Harland and Wolff single-acting two-stroke, opposed piston diesel engine, four cylinders 620mm diameter by 1870mm combined stroke, 118 r.p.m.—Launch, February 14.

KONINI, coaster ; built by Henry Robb, Ltd., for the Union Steam Ship Company of New Zealand, Ltd.; length between perpendiculars 250ft, breadth moulded 41ft 6in, depth moulded to upper deck 17ft 9in, deadweight 2100 tons on 16ft mean draught, trial speed 11 knots ; four holds, capacity 106,000 cubic feet, eight 5-ton derricks, electric winches, three 114kW diesel driven generators ; Clark-Sulzer mark T.P.D.48 two stroke diesel engine, five cylinders, 1500 b.h.p. at 225 r.p.m.—Launch, February 15.

DINTELDYK, passenger and cargo liner ; built by the Wilton-Fijenoord N.V. Dok-en Werf Maatschappij for the Holland-America line ; length overall 504ft 3in, breadth 69ft, gross tonnage 11,200 ; 60 passengers ; six cargo holds, capacity 497,375 cubic feet ; one set of Pametrada cross compound turbines, 8500 s.h.p., service speed 16 knots.—Trial, February.

Catalogues and Brochures

ALMCO SUPERSHEEN DIVISION OF GREAT BRITAIN, Bury Mead Works, Hitchin, Herts. Leaflets giving details of barrel finishing equipment and applications, also "Process Specification Control Card," a process for the accurate recording of the results.

STONEBRIDGE ELECTRICAL COMPANY, Ltd., 6, Queen Anne's Gate, London, S.W.1.—Illustrated leaflets giving details of weather-sensitive controllers for central heating, oil burner controls and a thermostatic control for modulating valves.

PORTER ELECTRICAL PRODUCTS, Ltd., 2, North Park Road, Harrogate.—Pamphlet entitled "The Portaway Earth Continuity and Bonding System," giving details of a complete earthing system, and also of the bonding and installation of the system.

BARIMAR, Ltd., Barimar House, 22-24, Peterborough Road, Fulham, London, S.W.6.—Illustrated booklet giving details of a complete service for the welding and machining of all classes of broken machinery in all metals and alloys either on site or at the factory.

CRYPTON EQUIPMENT, Ltd., Bridgwater, Somerset.—Leaflets describing the "Hydrolek" test meter for checking vehicle batteries, regulators and charging circuits, and the "Batterymaster," a heavy duty battery servicing equipment and engine starter.

SIMON-CARVES, Ltd., Cheadle Heath, Stockport.—Illustrated booklet describing "Baum Jig" coal preparation plant. Details of the development of this system are given. Flow diagrams are included of the "Baum" washery and of the "Baum" and Feldspar jig washery.

HARRIS ENGINEERING COMPANY, Ltd., York Works, Browning Street, London, S.E.17.—Illustrated planning manual giving details of "Trion" electronic air filters, which the manufacturers claim will remove in excess of 90 per cent (photometric basis) of all particles, regardless of size.

SOILTEST INCORPORATED, 4711W, North Avenue, Chicago, 39, Illinois, U.S.A.—1956 catalogue describing and illustrating a range of engineering test apparatus for soils, concrete and asphalt. Agents in this country are Van Colle Brothers, 9, Mayfields Close, Wembley Park, Middlesex.

FIRE PROTECTION ASSOCIATION, 15, Queen Street, London E.C.4.—Bulletin entitled "Electricity—and Fire," giving details of some of the common causes of electrical fires and the steps that can be taken to combat them. It is stated in the bulletin that electricity is the largest single cause of fire in buildings, being responsible in 1955 for more than 17 per cent of the total number of fires reported.

COMLEY AND PITT, Ltd., Pennsett Trading Estate, Brierley Hill, Staffs.—Illustrated leaflet describing the "Compit" scaffold-jacking system, which takes the form of an adjustable platform between two upright posts. The platform is supported at each end by a jack which can be operated by the worker on the platform. The scaffold-jack can, states the manufacturers, be erected or dismantled in a matter of minutes.

LAFARGE ALUMINOUS CEMENT COMPANY, Ltd., 73, Brook Street, London, W.1.—Illustrated brochure giving details of "Secar 250," a white high-alumina hydraulic cement, giving the user of refractories a castable refractory concrete capable of withstanding temperatures up to 1800 deg. Cent. (3300 deg. Fah.). Mix proportions, properties of various "Secar 250" refractory concretes and general notes on their uses are included.

THE THERMAL SYNDICATE, Ltd., P.O. Box No. 6, Wallsend, Northumberland.—Booklet describing "Vitreosil" electric immersion heaters, which have hitherto been fitted with rubber caps. To overcome the attack of chromic acid, which ultimately causes rubber to deteriorate, immersion heaters having P.V.C. caps have been developed. Instructions for assembling and installing the immersion heaters are included together with a price list.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., Metals Division Imperial Chemical House, Millbank, London, S.W.1.—Brochure giving technical details of "Alumbro" aluminium brass tubes and fittings for oil tanker heating coils. Illustrated folder giving particulars of "Kynal" roll-welded heat transfer sheets, including the method of manufacture, some applications, and the sizes available.

Booklet containing a brief review of methods of manufacture of rods and sections, including a detailed account of alloys available for particular applications. Many pages of useful tables are included.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, May 3.—LIVERPOOL BRANCH : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "Electrical Installation in Modern Cargo Vessel," A. Robertson, 7.30 p.m.
Mon., May 6.—LEEDS BRANCH : Great Northern Hotel, Leeds, "Synchronous Electric Clocks," 7.30 p.m. ★ N.E. LONDON BRANCH : Angel Hotel, Ilford, "Electricity in the Paint Industry," M. D. Blackley, 7.30 p.m. ★ N.W. LONDON BRANCH : Century Hotel, Forty Avenue, Wembley Park, "Technical Films," P. A. Thorogood, 8.15 p.m. ★ SHEFFIELD BRANCH : Royal Victoria Station Hotel, Sheffield, "Visual Call Systems," 7.30 p.m.
Tues., May 7.—LUTON BRANCH : Chamber of Commerce, George Street West, Luton, Films, 8 p.m. ★ OXFORD, READING AND DISTRICTS BRANCH : Palmer Hall, West Street, Reading, Annual District Meeting, 7.15 p.m. ★ TYNESIDE BRANCH : Crown Hotel, Newcastle upon Tyne, "The Nightstor Story," E. H. Parker, 7.30 p.m.
Wed., May 8.—BIRMINGHAM BRANCH : Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, Film Show, 7.15 p.m. ★ BRADFORD BRANCH : Midland Hotel, Bradford, "Bird Watching on the East Coast," F. Brook, 8 p.m. ★ CENTRAL LONDON BRANCH : White Hall Hotel, Bloomsbury Square, London, W.C.1, Film Show, 7.30 p.m. ★ HALIFAX BRANCH : Crown Hotel, Horton Street, Halifax, "Developments in Fluorescent Lighting," J. W. Bessant, 7.30 p.m.
Fri., May 10.—BRISTOL AND WEST OF ENGLAND BRANCH : Grand Hotel, Bristol, "Presentation Lighting," C. R. Passmore, 8 p.m. ★ STOKE AND CREWE BRANCH : Grand Hotel, Hanley, Stoke, "Earth Loop Testing," E. H. Lea, 7.30 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., May 4.—Science Museum Lecture Theatre, Exhibition Road, London, S.W.7, Film Shows, 2.30 p.m. and 6.30 p.m.

CHEMICAL SOCIETY

Thurs., May 9.—CENTENARY LECTURE : Burlington House, Piccadilly, London, W.1, "Structural Evidence Regarding the Solid Addition-Compounds of Ethers and Amines with Halogens and Other Molecules Acting as Electron Acceptors," O. Hassel, 7.30 p.m.

INCORPORATED PLANT ENGINEERS

Tues., May 7.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "Contemporary Plant Engineering in the U.S.A.," H. M. Sylvester, 7 p.m.
Thurs., May 9.—GLASGOW BRANCH : Scottish Building Centre, 425-427, Sauchiehall Street, Glasgow, "Developments in Boiler Feedwater Treatment," J. S. Couper, 7.15 p.m. ★ MERSEYSIDE AND N. WALES : Exchange Hotel, Liverpool, "Nuclear Reactors for Power Generation," J. A. Dixon, 7.15 p.m.

INSTITUTE OF METALS

To-day, May 3.—JOINT SPRING MEETING : All Day Visits.

INSTITUTE OF PHYSICS

Fri., May 10.—LIVERPOOL AND N. WALES BRANCH: Department of Electrical Engineering, University of Liverpool, "Rocket Exploration of the Upper Atmosphere," H. S. W. Massey, 6.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Fri., May 10.—S. WALES GROUP : South Wales Institute of Engineers, Park Place, Cardiff, "The Service Methods and Construction of Commercial Vehicles," C. H. Rowley, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

To-day, May 3.—SOUTHERN ASSOCIATION : Assembly Rooms, North Street, Chichester, Annual General Meeting, followed by Films, "Boring at Sea," and "Power for Uganda," 6 p.m.
Tues., May 7.—PUBLIC HEALTH (B) MEETING : Great George Street, Westminster, London, S.W.1, "Water Supply for Doha, Qatar," Charles Hogg and G. M. Swan, 5.30 p.m.
Tues., May 14.—ORDINARY MEETING : Great George Street, Westminster, London, S.W.1, James Forrest Lecture, "Large Telescopes," R. V. D. R. Woolley, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., May 6.—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2, Discussion on "The Co-ordination of Education and Practical Training in Sandwich Courses," opened by C. Grad and A. Draper, 6 p.m. ★ S. MIDLAND CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, Discussion on "The Influence of Maintenance Requirements on the Design of Industrial Electrical Equipment," opened by H. C. Fox and J. H. Harris, 6 p.m. ★ N. STAFFORDSHIRE SUB-CENTRE : North Stafford Hotel, Stoke-on-Trent, Annual General Meeting, "Electricity in Modern Commercial Horticulture," C. A. Cameron Brown and A. W. Gray, 7 p.m.
Tues., May 7.—MEASUREMENT AND CONTROL SECTION : Savoy Place, London, W.C.2, "Invention and Nature," F. W. Meredith, 5.30 p.m. ★ N. MIDLAND CENTRE : Central Electricity Authority, 1, Whitehall Road, Leeds, Annual General Meeting, 6.30 p.m. ★ N.W. CENTRE : Engineers' Club, 17, Albert Square, Manchester, Annual General Meeting, "Lighting for the Amateur Stage," F. Day, 6.15 p.m.
Wed., May 8.—N. SCOTLAND SUB-CENTRE : Robert Gordon's Technical College, Aberdeen, Annual General Meeting, followed by "Visit to Russia," J. S. Pickles and R. J. Rennie, 7.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION : Visit to Johnson and Phillips, Ltd., Charlton, Cable Manufacture, 2 p.m.
Thurs., May 9.—UTILIZATION SECTION : Savoy Place, London, W.C.2, "The World's Copper Resources," H. J. Miller, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, May 3.—GENERAL MEETING IN CONJUNCTION WITH THE APPLIED MECHANICS GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "Influence of Dynamical Imperfection on the Vibration of Rotating Discs," S. A. Tobias and R. N. Arnold, and "Free Undamped Non-Linear Vibrations of Imperfect Circular Discs," S. A. Tobias, 6 p.m.
Thurs., May 9.—SCOTTISH BRANCH : Visit to G. and J. Weir, Ltd., Cathcart, 7.30 p.m. ★ E. MIDLANDS GRADUATES' SECTION : Art Gallery (Strand Entrance), Derby, Annual Meeting, 7.15 p.m.
Fri., May 10.—GENERAL MEETING : 1, Birdcage Walk, Westminster, London, S.W.1, James Clayton Lecture, "Projection Planetarium and Shell Construction," Walther Bauersfeld, 6 p.m.
Tues., May 14.—LONDON GRADUATES' SECTION : 1, Birdcage Walk, Westminster, London, S.W.1, Annual General Meeting, "Modern Marine Propulsion," A. R. Hopwood and R. S. Saunders, 6.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Mon., May 6.—ORDINARY MEETING : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "The Rugby 'B' H.F. Radio Transmitting Station," A. Cook and L. L. Hall, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., May 15.—WOLVERHAMPTON GRADUATE SECTION : Wolverhampton and Staffs Technical College, Wulfruna Street, Wolverhampton, "Gas Turbines—Basic Principles and Production Difficulties," C. E. Wurr, 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

Thurs., May 9.—Visit to Thames Sugar Refinery of Tate and Lyle, Ltd., London, E.15, 2.15 p.m.

NEWCOMEN SOCIETY

Wed., May 8.—Lecture Theatre, Science Museum, South Kensington, London, S.W.7, Film Evening, 5.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., May 9.—MAIN LECTURE : Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, First Lanchester Memorial Lecture, T. von Kármán, 6 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., May 6.—ORDINARY GENERAL MEETING : Hoare Memorial Hall, Church House, Great Smith Street, Westminster, London, S.W.1, "The Rent Bill, 1957," R. E. Megarry, 5.45 p.m.

ROYAL STATISTICAL SOCIETY

To-day, May 3.—INDUSTRIAL APPLICATIONS LONDON GROUP : E.L.M.A., Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, "Some Simple Experiments," D. R. Cox, 6 p.m.
Wed., May 8.—STUDY SECTION : E.L.M.A., Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, a Discussion on "Some Problems of Statistical Inference," G. A. Barnard, M. G. Kendall and B. L. Welch, 6.15 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., May 7.—CORROSION GROUP : 14, Belgrave Square, London, S.W.1, Annual General Meeting, and Chairman's Address, "A Pilgrim's Progress from Corrosion," T. H. Turner, 6.30 p.m.
Wed., May 8.—CORROSION GROUP EDUCATION PANEL : 14, Belgrave Square, London, S.W.1, Annual General Meeting, 11 a.m.

SOCIETY OF ENGINEERS

Mon., May 6.—Geological Society, Burlington House, Piccadilly London, W.1, "Meteorology To-day," Sir Graham Sutton, 5.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., May 8.—LONDON BRANCH : Hope House, 45, Great Peter Street, Westminster, London, S.W.1, "The Future Prospects for Nuclear Power," J. V. Dunworth, 7 p.m.